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A web-based inventory, mapping and digitization of ornamental plants and flowers in Arusha city

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A WEB-BASED INVENTORY, MAPPING AND DIGITIZATION OF ORNAMENTAL PLANTS AND FLOWERS IN ARUSHA CITY

Kenneth Patrick Asiimwe

A Dissertation Submitted in Partial Fulfillment of the Requirements for the Degree of Master's in Information and Communication Science and Engineering of the Nelson Mandela African Institution of Science and Technology

Arusha, Tanzania

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ABSTRACT

There is a wide collection of invaluable varieties of ornamental plants and flowers available for sale by vendors in Arusha city contributing to local employment, and food security. Horticulture in Tanzania is dominated by small scale farmers in Arusha that contribute to about 70% of the produces in the sector. However, there are challenges that need to be addressed including; inadequate information for the development of the sector and livelihoods of the vendors. The information on the varied species of ornamental plants and flowers are mainly undocumented and not digitized. This limits access to the scientific community and the general public bringing on these varieties in Arusha a growing conservation concern. The other challenge is that the small-scale vendors have limited visibility to regional markets and international market places which hinders their business growth.

On this study, a Web portal was developed for inventory, mapping and digitization of the various species of ornamental plants and flowers as a solution to above challenges. Data collection was conducted using various data collection techniques such as; Interviews, observations, Questionnaire (Open Data Kit) and reviewing numerous research papers in seven wards of Arusha city where the vendors grow and sell a number of species of ornamental plants and flowers. Both qualitative and quantitative methods mentioned above were deployed to provide insights on the ornamental plants and flower business operations.

For the survey, 70 varieties of ornamental plants and flowers were gathered and arranged categorically in terms of taxonomy and usage and uploaded on the portal. The portal developed indicates the potential to help stakeholders find plants' and flowers' varieties information, images, and sales location online, the vendors will be able to advertise their products on the portal and conduct business with customers online. In addition, it will also help Arusha City Representatives with baseline information on the sector to make informed plans and decisions.

DECLARATION

I, **Kenneth Patrick Asiimwe** do hereby declare to the Senate of the Nelson Mandela African Institution of Science and Technology that this dissertation is my own original work and that it has neither been submitted nor being currently submitted for degree award in any other institution.

…… **……..…….**

Signature **Date**

The above declaration is confirmed

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Supervisor 1

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Signature **Date**

Dr. Mussa Ally Dida

Supervisor 2

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CERTIFICATION

The undersigned certifies that he/she has read and hereby recommend for acceptance by the Nelson Mandela African Institution of Science and Technology a dissertation titled, "A Web-Based Inventory, Mapping and Digitization of Ornamental Plants and Flowers in Arusha City, in fulfillment of the requirements for the degree of Masters in Information and Communication Science and Engineering of the Nelson Mandela African Institution of Science and Technology."

…… **……..…….**

Signature **Date**

Dr. Dina Machuve

Supervisor 1

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Signature **Date**

Dr. Mussa Ally Dida

Supervisor 2

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DEDICATION

This dissertation is dedicated to my beloved dad Mr. Asaba John

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LIST OF ABBREVIATIONS AND SYMBOLS

ACPM	Antipoison Center and Pharmacovigilance of Morocco
AJAX	Asynchronous JavaScript
BRAHMS	Botanical Research and Herbarium Management System
CEPDEC – GBIF	Chevron Project Development and Execution Process - Global Biodiversity Information Facility
CSS	Cascading Style Sheets
CSV	Comma Separated Values
DFD	Data Flow Diagram
DOS	Disk Operating System
ERD	Entity Relationship Diagram,
FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
GPS	Global Positioning System
GUI	Graphical User Interface
HTML	Hypertext Markup Language
ICT	Information and Communications Technology
ISP’s	Internet Service Providers
IUCN	International Union for Conservation of Nature
JSON	JavaScript Object Notation
MySQL	Structured Query Language
ODK	Open Data Kit
OS	Operating System
PDO	Hypertext Preprocessor Data Object
PHP	Hypertext Preprocessor
PROTA	Plant Resources of Tropical Africa
TanBIF	Tanzania Biodiversity Information Facility
TCRA	Tanzania Communications Regulatory Authority
XML	Extensible Markup Language

CHAPTER ONE

INTRODUCTION

1.1 Background of the Problem

Horticulture is a significantly huge investment and dynamic industry which deals with thousands of species and variety of ornamental plants and flowers. Europe is the leading producer of ornamentals with the biggest market share occupied by the Netherlands (35%), Italy (18%) and Germany (11%) (Neltnou-Nkoana, 2010). In Africa, ornamental production has improved in the past decade with Kenya ranking first, followed by Tanzania, South Africa and Uganda respectively. This is attributed to the adoption of ICT and technology in the ornamental sector in Africa (Donovan, 2014). For example, greenhouse technology, fertigation systems, innovative forms of water treatment and recirculation techniques, modern acclimatization and heating technologies, and applied highly sustainable crop protection methods to reduce environmental hazards have been integrated in the horticulture sector creating remarkable diversity in the horticulture sector (Fukase & Martin, 2018). However, the adoption of ICT in horticultural production is still a challenge (Jerusalem, 2016).

Horticulture in Tanzania has for several years been a backbone of growth and development with an estimated annual growth rate between 6% and 10% per annum (Mrema, Ngowi, Kishinhi & Mamuya, 2017), contributing to about a quarter of the GDP. The sector also employs nearly three quarters of all Tanzanian workers contributing to local employment and food security (DLV, 2015). The horticulture sector is dominated mainly by small-scale farmers (vendors) in Arusha City selling ornamental plants and flowers mostly on road sides (streets).

The export oriented horticultural sector is concentrated in Arusha (Oswald, Vivian & Specioza, 2013), located in North-Eastern part of Tanzania, at the foot of Mount Meru at an altitude of 1400 meters is the major industrial center and exotic center of growing and exporting flowers in Tanzania where by 20% of the flowers are exported which includes a wide range of ornamental plants and flowers among various species ranging from ornaments (African Lily, Tuberose, endemic orchids), herbal (Rosemary, Basil), insects repellents and fragrant (air fresheners) (Allure-Flowers, 2018). The small-scale farmers contribute about 70% of the produces in the sector and also cannot export their produce since they are not connected to regional and international market (Associates, 2017).

However, horticulture particularly in Tanzania is challenged with inadequate access to information by stake-holders that include researchers and buyers. Also, there is lack of awareness by stakeholders within Tanzania and internationally about economic and social potential of horticulture sector (HODECT, 2012). There lacks access to information on varying species of ornamental plants and flowers in Tanzania (Embassy of the Kingdom of the Netherlands, 2017).

The information on plants and flowers is not only a contribution to the cultural heritage of any country like Tanzania but also of significance for scientific and practical interest (Magwede & Wyk, 2018).

Conservation of the various species of ornamental plants and flowers relies heavily on official statistics, but since the information is not digitized and documented, much is absent on the official statistics bringing about a growing concern on conservation (Hinsley *et al*., 2018).

Therefore, this study aimed to document, digitize, and map the ornamental plants and flowers in Arusha City on the web portal. The web portal will be freely accessible online that will not only provide profile information of horticulture in Arusha but also act as a marketing tool in order to connect the vendors to regional and international markets.

1.2 Statement of the Problem

There is a wide collection of invaluable varieties of ornamental plants and flowers available for sale in Arusha city which contribute to reduction of carbon foot print (Sharrock, 2014); however the information on the various species of the plants and flowers are mainly undocumented and not digitized. Knowledge, skills, challenges, experience, location of the vendors and farmers in the horticulture sector is undocumented, not digitized and therefore unknown to the scientific community and the general public. There is need to document and digitize the above information in order to provide knowledge so as to understand the ornamental plants and flowers diversity on which conservation plans and action can be based (Jackson *et al*., 2015). Therefore, the study aimed at inventory, mapping and digitizing of the above information.

1.3 Rationale of the Study

We are in the information age where every sector to grow and develop demands easy flow, sharing and access to information. The study aims to lay down a ground for easy access of information on the various species of ornamental plants and flowers for the scientific community and the general public to be aware of the different species in the country. Additionally, the vendors can advertise their products and make sales online as the clients will easily locate them thus improve on their businesses and in long run improve on their livelihoods. The study also lays a foundation for the policy makers to be able access important information to make informed plans and decision that will develop the sector even more. In a nut shell, the proposed will study have the following contributions;

i. The study will provide a mobile responsive web portal that will pave way for biodiversity institutions to digitize their variety collection of the variety species of ornamental plants and flowers in Arusha, a conceptual design of database systems that can be used in the implementation of a centralized database for digitizing information on variety species of ornamental plants and flowers for easy and free access online to be used as an appropriate technology.

ii. The study informs on how to employ the use of open source, easy to use software in the development of a web portal for inventory, mapping and digitization of ornamental plants and flowers in Arusha City.

iii. The study also introduces a web based portal that can be used by botanists, researchers and the entire scientific community to find ornamental plants' and flowers' important information (taxonomy), images and sales location and also for vendors to be able to advertise their various categories of products to increase on their reach as far as marketing is concerned online.

1.4 Objectives

1.4.1 Main Objective

To develop a web-based portal for inventory, mapping and digitizing ornamental plants and flowers.

1.4.2 Specific Objectives

i. To establish baseline information related to horticulture, small and medium enterprises by vendors in Arusha City.
ii. To develop a web-based portal for ornamental plants and flowers for all stakeholders of the Horticulture in Arusha City.
iii. To validate the web-based portal with stakeholders.

1.5 Research Questions

i. What is the profile of the horticulture industry in Arusha City Council?
ii. How can the development of inventory mapping and digitization of ornamental plants and flowers be achieved?
iii. What value is added by the web-portal to horticulture enterprise in Arusha City Council?

1.6 Significance of the Study

Ornamental plants are significant and made a breakthrough in the economic sector in the 20th century and the increase in demand of ornamental plants has led to profits accumulation in this sector with its continuous development in the developing and developed countries. The level of technology in the production of ornamental plants has brought about a level or phase where this sector is defined as the 'ornamental plants sector' now (Çelik & Arisoy, 2013). Therefore, the developed web portal will enable increase in visibility of the vendors' products in the regional markets and international market places thus will increase on their sales, profits and growth of their businesses and improvement in their livelihoods.

Biodiversity wealth in Tanzania includes among other plant species 109 ornamentals and 34 plants species of herbs recorded (URT, 2009). Horticulture in particular dictates rural economy in Tanzania contributing to local employment and food security. Therefore, the development of this sector is significant and unavoidable and in turn will offer many opportunities for investments, technology suppliers and knowledge institutes (DLV, 2015). With the developed web portal, 70 varieties of ornamental plants and flowers have been documented and digitized with important information on their taxonomy, image, usage and their location to be freely accessed online.

Recently, there has been a significant growth in developing regional inventories for the floral industry in the world. For example, Russia on alien plant species. Such inventories signify key contributions and inputs for continental and global database that provide data for testing hypothesis (Vinogradova *et al*., 2018). With the developed web portal for Arusha City provides a regional inventory of the area thus contributing to growth of regional inventories.

Thorough research and growing programmers are still essential in order to create a good profitable production of ornamental plant species. However, involvement from institutional and policy support is essential for developing new approaches in floriculture industry and protection and management of these ornamental plant species particularly (Negi, Tiwari, Mehta & Rawat, 2016).

The portal developed indicates the potential to help stakeholders find plants' and flowers' varieties, images, and sales location online. In addition, it will also help Arusha City Representatives with baseline information on the sector to make informed plans and decisions.

The developed web portal will be used by the small-scale vendors to market their products thus empowering them with ICT adaptation leaving the traditional ways of marketing such as road sign posts, customer referral etc.

1.7 Delineation of the Study

This study considered only respondents whom were free and ready to participate. The study excluded people who were hesitant and those who indicated negative attitude towards this kind of studies, this was done purposely to avoid responses which are not genuine. Additionally, the study did not aim at developing a mobile although the developed web portal is mobile responsive platform as shown in Appendix 7 and also the visualization tool that was embedded on the web portal is predefined by the programmer as it does not give room for users to determine which data they want to analyze.

CHAPTER TWO

LITERATURE REVIEW

2.1 Horticulture in Africa

Horticulture is regarded as an economic remedy for several developing countries with good climate conditions and in endeavors to expand the agricultural sector. Horticulture has arose as one of the sectors which African countries can boost GDP due to the high demand of the ornamental plants and flowers by developed countries in world especially in Europe, Asia and America thus enthusiasm for developing countries in Africa to involve in horticulture and that is why most of the flowers grown in Africa are exported to the European Union (Mwase, 2015).

Many developing countries in the world have an interesting diversity of ornamental plants that could add value and contribute to economic growth and development. For instance in South Africa, flower production sector is one of the biggest contributors to her economic growth, creating employment for 75 000 people, income generation and wealth creation with in the local economy of the country (Neltnou-Nkoana, 2010).

2.1.1 Horticulture in Tanzania

Most small holder famers are found in urban city areas like Arusha City specifically on road reserves (open spaces) growing ornamental plants and flowers for sale. Most of these urban farmers have chosen to take up the informal sector as a strategy to survive as it has provided them and their families with employment, food security and income. These urban farmers are mainly women without sufficient skills to get well-paying jobs, self-employed people, and low wage workers. Most of these horticulture land in open spaces (road reserves) are owned by institutions or private individuals and these small holder farmers have an understanding with the owners of the lands and mostly are open public spaces like under main power lines, railway reserves and its presently just tolerated by the authorities (Dongas, 2001).

2.1.2 Internet use in Tanzania

The internet use in Tanzania is growing steadily and promising. It is estimated that there were 1.4 million subscribers in Tanzania on internet served by several (ISPs) internet service providers in the country. According to the Tanzania Communications Regulatory Authority (TCRA), the total number rose by 16% in 2017 to 23 million. Among the internet users are

also, institutions, internet cafes. However, there are still challenges in the ICT sector that Tanzania needs to address such as lack of local experts, well-trained users and pronounced divide between the urban and rural in terms of ICT use among others (Adam & Esselaar, 2013).

2.2 ICT in Horticulture

2.2.1 Benefits of using ICT in Horticulture

The use and application of ICT is extremely important as it provides timely, accurate, and relevant information to farmers if adopted well and in turn improve on social economic benefits and also contribute to rural development as many jobs are created, more productivity is achieved with the use of ICT thus food security is improved (Mahant, Shukla, Dixit & Patel, 2012).

Information and Communications Technologies (ICTs) have changed how businesses, governments and people work. They have many benefits such as reduction in transaction costs and facilitation of easy way of communication among stake holders. Farmers can now be up-to-date than before if the ICT is integrated and well adopted. Information and Communications Technologies (ICTs) involve digital technologies which promote inclusion and efficiency as several tasks or jobs can be carried out with minimal costs and many services can reach farmers that previously lacked access (FAO, 2017).

Information and Communications Technology (ICT) has affected the production of ornamental plants and flowers in several ways from photosynthesis capacity, plant protection, and mode of production, nutrition, and specific management. Such information is highly based on advanced knowledge regarding to the biology of the species to be explored. Information and Communications Technology (ICT) gives a basis to share such information worldwide to the scientific community via the internet especially for young scientists and researchers (Pompelli De-Brito, Otoni & Guerra, 2007).

According to Siti, Bahaman, Salleh, Hassan and Zobidah (2015) Information and Communications Technology (ICT) can solve agriculture problems such as lack of guaranteed access to markets, lack of information and market infrastructure, volatile and low prices, and poor information management particularly on latest market prices, and supply of stock for both long-term and short-term markets

2.2.2 Challenges of using ICT in Horticulture

Internet subscriptions have continued to increase and there are many benefits of integrating and adopting ICT in production of ornamental plants and flowers. There are still challenges such as lack of access to internet by rural farmers, lack of capacity and skills to use computers, and smart phones to access information that would be significant to their activities. Such information include correct and timely information on markets, production processes, crops and livestock disease, as well as access to services such as land registration databases, permits, and information on government regulations (Katalyst, 2011).

2.3 Related Systems Currently in Existence

2.3.1 Fairtrade Deutschland

Fairtrade Deutschland is a web-based portal mainly in German but that can also be translated to English. The site links consumers, businesses and producers of various plants including ornamental plants and flowers like cut flowers and roses, but mainly certifies the flowers exported to various countries like Holland and Germany (Fairtrade, 2018). It is more of a marketing tool since it provides packaging services and provides an online shop for variety of these flowers grown in Africa and in the country where producers and consumers can sell and buy respectively these flowers (Fairtrade, 2018). For example, Mount-Meru flowers who are involved in the growing and supplying variety of flowers such as roses use Fairtrade Deutschland services as those mentioned earlier to do their business. Various growers' profiles on individual level are posted on their website and you tube channel, their skills and challenges also posted (Mount-meru-flowers, 2018) but undocumented plus their location excluding the vendors profile on local streets of Arusha. The web site also does not provide enough data on the various species of ornamental plants and flowers, no documentation provided on these flowers which could be used for further research. The developed web portal aimed at document this data and digitize the data, create an inventory and map this data in a database on various species of ornamental plants and flowers in Arusha including their general names and botanical names, vendor's profiles including those on the streets of the city, challenges they face, methods they use to grow and sell these plants and flowers, knowledge they have, where they are located and at the end come up with a web-based portal which will be used to access this information from the database and also use it as a marketing tool and lastly make information available for further research.

2.3.2 Agrislide Zone

Agrislide zone in India is a web-based portal that provides information on agriculture. Information on pest and disease management, vegetable farming, fruit farming and flower farming including tutorials and guidelines for beginners. It also provides a classification and a list on various species of ornamental plants and flowers with their local names, scientific names, family names with the corresponding pictures. It also provides some documented content available freely to download regarding information mainly on fertilizers (Agriculture-information-zone, 2018). However, it does not provide information on the location of these ornamental plants and flowers, profile of producers and vendors involved, and generally not enough information available for researchers. Therefore, the proposed project is aimed at solving this information gap and include inventory on location of these ornamental plants and flowers specifically in Arusha and provide large and enough information that could be used for further researchers.

2.3.3 Plant Database

Plant database is under the United States department of agriculture which provides standardized information on the various plants, plant symbols, images, crop information among other information mainly in the United States and its territories also making information exchange possible across multiple disciplines and agencies (United-States-Department-of-Agriculture, 2018). However, to use this data base, one has to be knowledgeable on what exactly he or she is searching for thus requires technicality to use it. The proposed project will ensure that even normal users who are not knowledgeable can search results and get them instantly based on the keywords entered by the user.

2.3.4 Global Naturalization Alien Flora (GLONAF)

This earlier focused on bringing together data on the naturalized alien vascular plant species in different parts of the world but now also focuses on bringing together inventories with the identities of the naturalized vascular plant species. This project was developed to solve a problem of use of jaggy and incomplete data on the number of naturalized alien species richness that was used by researcher. However, the full version of the GLONAF data (North America, Europe and Australasia) are not yet freely available much as they are open to project proposals and data requests (GLONAF, 2018). The proposed project is however aimed at bringing together information on the various species of ornamental plants and flowers in Arusha and

map them into a database which will be accessed through a web-portal that would be efficient to use and this information will be freely available for all users.

2.3.5 Botanical Research and Herbarium Management System (BRAHMS)

Botanical Research and Herbarium Management System (BRAHMS) was published on January 1st 1985 by University of Oxford, the department of Plant Sciences is a flexible database management system for botanical herbaria and researchers, with comprehensive and advanced features to manage, assemble, analyze publish and edit botanical data. The system is used by projects in over 60 countries worldwide. The system was designed specifically for botanical collections, which includes resources online mainly for training and wide-ranging help and support documentation. Botanical Research and Herbarium Management System (BRAHMS) provides comprehensive support with the catalogue and management of species data, collection curation, floras checklist, taxonomic, research, analyze, publishing online and mapping (John, 2016). However, BRAHMS uses DOS (Disk Operating System) which is not easily understood by an ordinary user since it does not have a GUI (Graphical User Interface) like windows, DOS is an out dated and obsolete operating system. Additionally, version 8 is not free as it requires license. The web portal developed will run on all modern operating systems and will be availed free of charge. Additionally, it is easy to use with user-friendly interfaces.

2.3.6 Tanzania Biodiversity Information Facility (TanBIF)

Tanzania Biodiversity Information Facility (TanBIF) is a national node of the GBIF (Global Biodiversity Information Facility) based in Tanzania. Tanzania Biodiversity Information Facility (TanBIF) promotes mobilization, sharing and utilization of biodiversity data and information in Tanzania and through 4 years of its capacity enhancement project (CEPDEC-GBIF Pilot Project) considered digitalizing local Institutions biodiversity collections. However, TanBIF could not finish the digitalization process due to limited funds, the country has limited human capacity on biodiversity collections digitalization, digitalization start-up costs was far high for most Tanzania biodiversity collection hosting Institutions and this explains why Tanzania has numerous small institutional collections, but not digitized (Nyinondi & Gideon, 2016). Additionally, TanBIF is yet to be online. The web portal developed is available online and supports easy to use digitization of ornamental plants and flowers in Arusha. Since it is easy to use, it does not require much effort and cost in training.

2.3.7 Plant Resources of Tropical Africa (PROTA4U)

Plant Resources of Tropical Africa (PROTA4U) in South-East Asia is a dynamic and highly interactive digital encyclopedia of useful plants of Tropical Africa. It consists of two elements namely; validated part containing 1200 'PROTA articles' with comprehensive information on 2100 plant species. These articles have been reviewed and validated by a network of PROTA scientific editors and an interactive part with over 8000 species records, called 'starterkits', with non-validated information obtained from PROTA's supporting databases and metadata mined from the internet. Visitors are encouraged to comment on PROTA articles or to adopt a 'starterkit' species and deliver data to enable editors to transform it into a PROTA article. However, its interface is not attractive therefore users can not have good experience using it, it also does not have clear images of the variety species and also does not map the location of the species recorded. The web portal developed is attractive to use and user will have great experience, the web portal provides mapping of the ornamental plants and flowers collected and recoded.

2.3.8 The Plant List

The plant list was founded in September 2013 by a collaboration between Kew, Missouri Botanical Garden and the Royal Botanic Gardens by combining several checklist databases owned by these institutions. The aim was to be comprehensive for species of Bryophytes (liverworts and mosses), Vascular plant (conifers, ferns, flowering plants and their allies). It provides accepted names in Latin for most species with synonyms to which species are known (Chirinko, 2008). However, it does not provide common and vernacular names of the above-named species. The developed web portal provides common and vernacular names of the variety species of ornamental plants and flowers.

2.3.9 The Red List

The Red list in the United Kingdom was initiated in 1964, it is the greatest complete inventory of universal conservation status of biological species in the world. It uses a set of criteria to evaluate the extinction risk of thousands of species and subspecies. These criteria are relevant to all species and all regions of the world. With its strong scientific base, the IUCN Red List is recognized as the most authoritative guide to the status of biological diversity (Vié *et al*., 2008). However, it is only limited to providing conservation status of the variety species of plants and flowers. The web portal does not only provide the conservation status of the variety species of

ornamental plants and flowers but also provide other important information (taxonomy) of the variety species.

2.4 Related Works

A study by Negi *et al*. (2016) sought to develop an inventory and botanical identity of seasonal flowering plants grown in home gardens in the District of Nainital, Uttarakhand. From the survey that was carried out from 2013 to 2015, a list of 150 seasonal flowering plants with 120 genera belonging to 50 families were collected, recorded with their botanical names, vernacular names, trade names, family, native, nature, season with appropriate remarks of variation in shape and color, method of propagation with economic status and photographs. The study also came up with a statistical summary of the number, percentage of families, genera, and species. The survey, nevertheless, did not provide conservation status of the seasonal flowering plants and also did not map the location of the house, gardens, villages where they carried out the survey, did not offer a statistical summary of the pricing of the plants, challenges faced by farmers growing and selling the seasonal flowering plants. Additionally, the study did not provide visualization of the data collected from the survey. Lastly, the inventory does not provide visualization of the data of the ornamental plants collected.

A study by Park *et al*. (2018) was aimed at coming up with a Floristic inventory on vascular plants mainly in Nam Ba National Biodiversity conservation area of the Lao people's Democratic Republic. From the joint field survey that was conducted by the Korean and Lao's experts in the year of 2015 to 2017, it was recorded that there were 33 species of ornamental plants among others such as species of edible plants, species of economic plants, families and genera distributed in the Nam Ba National Biodiversity conservation area. The study provided scientific names, families and genera of the vascular species. However, did not provide vernacular names, trade names, native places, images, and description of the vascular plants by color, shape, size, and method of propagation, economic status of the ornamental plants.

The Antipoison Center and Pharmacovigilance of Morocco (ACPM) produced a report with a concern on poisoning caused by plants. This sparked off the study by Benzeid *et al*. (2018) which aimed to come up with an inventory of toxic plants in Morocco that would enable the necessary study on their nature and monographs. This was aimed to separate the good plants such as the ornamental plants from the toxic ones since it was found out that some plants are toxic and cause various disorders in both human beings and animals. The Antipoison Center

and Pharmacovigilance of Morocco (ACPM) required this study so as to sound an alarm on these poisonous plants in the country. The study came up with a list of the most toxic plants in Morocco and provided them with the French name, vernacular name (Moroccan), family name to which these toxic plants belong to. However, the study did not provide the native places, genus, and described by size, color, shape, images of the toxic plants, economic status (prices) of the sold plants, and visualization of the data collected on the toxic plants. Additionally, the inventory does not provide visualization of the toxic plants.

The study by Plugatar, Koba and Mitrofanova (2015) was aimed at addressing the urgent problem which was identified as inventory with bio ecological assessment of vital state and growth conditions of ornamental arboreal plants regarded as the main structural elements landscape composition. One of the objectives of the study was to form the collection of the ornamental and other valuable plants economically such that they could be analyzed to reveal their characteristics so as to select them and propagate the most perspective plant species. Fortunately for Nikita Botanical gardens, a rich collection on these plants was created due to the work of generation of researchers. The inventory provides bio ecological assessment of dendrological collection (trees, shrubs, and lianas) thus, trees (42.2%), polubushes (1.5%), bamboos (0.7%), liana (8.2%), bushes (47.4%). However, the inventory does not provide trade names, vernacular names, families, genus, and order of the ornamental arboreal plants. Additionally, the inventory does not provide visualization of the ornamental plants.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Study Area and Scope of the Research

The research was conducted in Tanzania specifically in areas of Arusha City where the horticultural sector activities are concentrated. The various invaluable ornamental plants and flower products exported are mainly from the Northern part of Tanzania mainly from Arusha region (Oswald, Vivian & Specioza, 2013). Arusha is a region that is located in Northern Tanzania and to the East of Kilimanjaro and Tanga regions. It also shares a boarder in the South with Dodoma and in the West Singida, Mara and Shinyanga regions (Odi.org, 2017). Arusha is strategically located with good geographic conditions, good climate suitable for growth of ornamental plants and flowers and thus many vendors carry out their businesses in these areas. Figure 1 shows the map of Arusha region with wards where ornamental flowers vendors are located and the study sites of this research project.

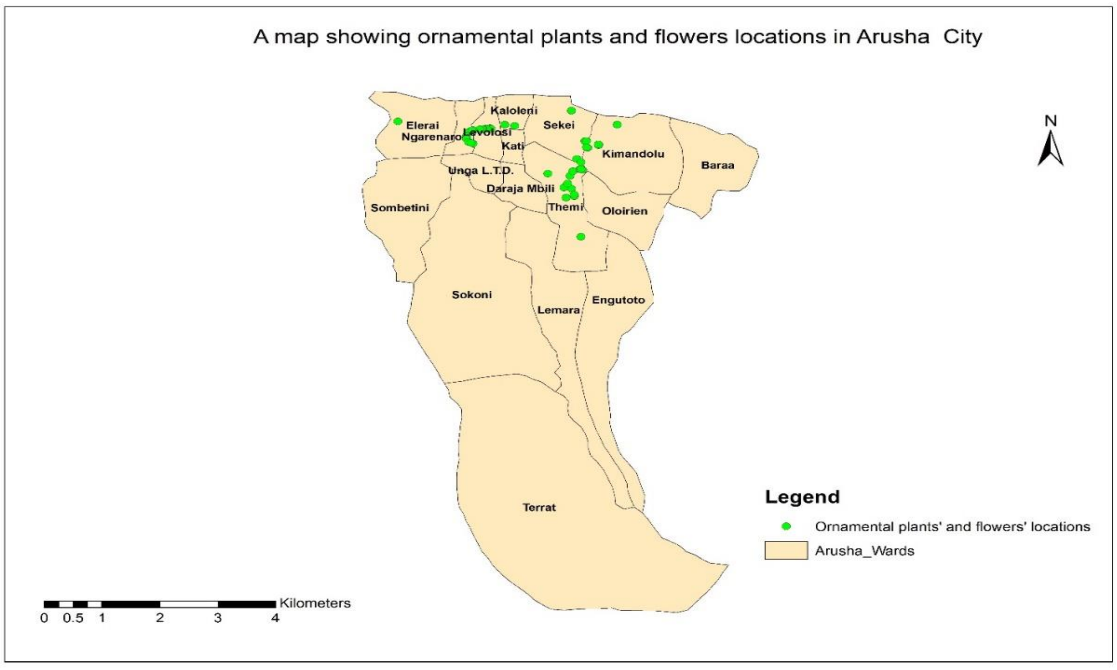

Figure 1: Map of Arusha Mapping Location of Ornamental Plants and Flowers

3.2 Development Approach

Evolutionary prototyping methodology was selected and used to develop the system. It allows for user involvement throughout the system development duration leading to user requirement satisfaction (Zamperoni, Gerritsen & Bril, 1992). Figure 2 shows the evolutionary prototyping methodology cycle.

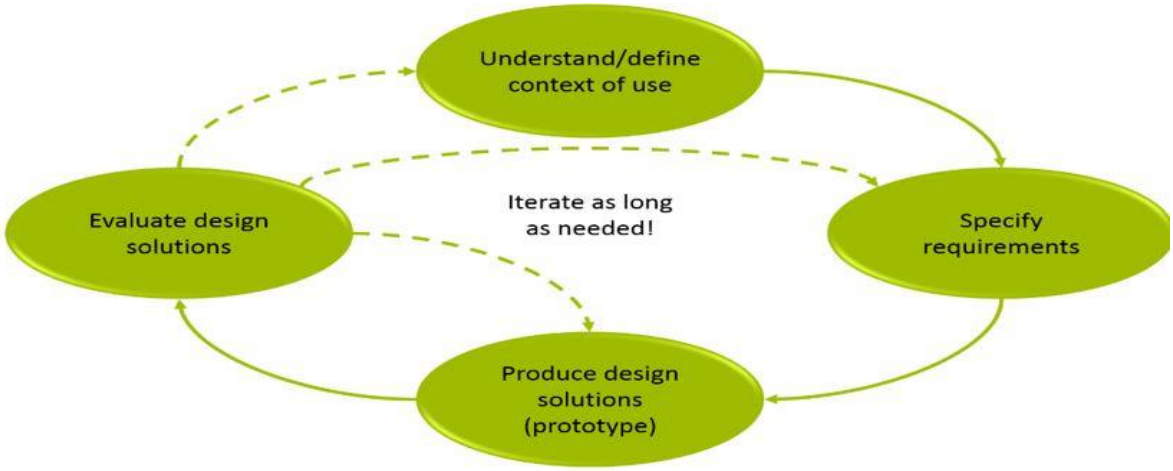

Figure 2: Prototype Development Life Cycle

Evolutionary prototyping was chosen because, the implementation is commenced when the requirements are best understood unlike rapid prototyping where the implementation starts with the least understood requirements (Sherrell, 2013). Table 1 shows the comparison of evolutionary prototyping versus waterfall and spiral methodologies in terms of flexibility, client interaction and phase containment error**)**

Table 1: Comparison of Evolutionary Prototyping Versus Other Methodologies (Chandra, 2015)

Methodology	**Flexibility**	**Client Interaction**	**Phase Containment of Error**
Waterfall	No	One time	Low
Spiral	Few	Some time	Low
Evolutionary Prototyping	Fully	Frequent	High

3.2.1 Sample, Sample Size and Sampling Technique

The sample of the study comprised of the vendors in Arusha City that are actively selling the ornamental plants and flowers. An Open Data Kit (ODK) Collect application was configured, installed on a smartphone inform of an electronic questionnaire whereby we managed to sample 48 respondents in seven wards in Arusha City namely; Themi, Sakina, Sekei, Levolosi, Kaloleni, kati and Ngarenaro. In this case, vendors were selected by chance and were all given equal opportunity and carefully asked questions and got input which was filled in the ODK application and saved.

3.2.2 Data Collection Methods

Data collection was carried out in a period of four weeks in March 2019. In this study, interview, questionnaires, document review and observation methods were used.

i. Interview

A structured interview with guiding questions involving the vendors in Arusha City Council was conducted. The main objective of this activity was to understand the brief history and profile of their business, challenges they face, the techniques they use in the operations of their business of selling ornamental plants and flowers.

ii. Questionnaire

An ODK Collect application replacing paper based questionnaires was configured in an android phone that contained designed straight forward questions, close-ended questions and multiple-choice questions. The objective was to identify the procedures and practices of activities of the vendors, take their location using GPS, and also images of the invaluable species ornamental plants and flowers that the vendors are growing and selling.

iii. Observation

Observation was done from the vendors' road reserve open spaces which is also a place where they sell the invaluable species of ornamental plants and flowers thus streets on the roadside. The objective of this activity was to establish a clear concept or perspective corresponding to vendor's responses specifically on challenges they face, and procedures they go through to grow and sell the ornamental plants and flowers.

iv. Document Review

This involves reading different works related to the area of the study such as manuals and other organizational documents to get more information. This was done mainly to obtain taxonomy of the variety species of ornamental plants and flowers that were gathered and arranged categorically by the scientific names, family names, native and more descriptive among other information on the variety species of ornamental plants and flowers in Arusha City (Appendix V).

3.2.3 Data Analysis Methods

Through questionnaires (ODK Collect application), interviews, document reviews and observations methods both qualitative and quantitative data was collected during the study. The fully filled questionnaires (ODK Collect application), were sent into electronic forms with respective responses in the Google drive excel sheet. After coding and filling all responses, then a CSV file was exported from Google drive excel sheet. The exported CSV file was extracted and uploaded into python library software tool called pandas for data analysis using python programming language.

3.2.4 Requirements Analysis

User requirements were collected, analyzed and later categorized into two that is functional and non-functional requirements.

i. Functional Requirements

Functional requirements describe what the system should do (Gabriela, 2017). For example, what inputs the system should accept, what outputs the system should produce, what data the system should store that other systems might use, what computations the system should perform, the timing and synchronization of the above. Table 2 shows the functional requirements of the ornamental web portal.

Table 2: Functional Requirements

Requirement	Description
Registration (Users, Vendors)	Web portal shall allow registration and login for access of exceptional information and guidance customized for a specific type of users, the administrator will register vendors and also vendors can register and await approval from an administrator, same applies to all new users
Manage user Accounts	The administrator shall Add, delete users and vendors.
Add ornamentals (upload/delete images)	The administrator shall be able to upload images of the ornamentals and add information of ornamental plants and flowers
Search	Users and Administrator shall have an advanced search option to ease on information retrieval
View ornamentals	A system shall be able to display the information of ornamental plants and flowers.
Visual Data	The administrator shall be able to upload a CSV file in the database for visualization, users should be able to select entries and perform visualization.
Chat	The system shall provide access to chat rooms for vendors, botanists and other users, store messages in chatrooms, display messages in group chatrooms
Add/delete Advert	The system shall provide access to the vendors to advertise their products and delete the advert
Place Order	The system shall allow clients to place order on advertised products by vendors.

ii. Non Functional Requirements

Non-functional requirements consist of constraints that must be adhered to during development (design and implementation) of the system (Shahid & Tasneem, 2017). Therefore, they describe how the ornamental web portal system should perform as explained in Table 3.

Table 3: Non Functional Requirements

Requirement	Description
Performance	A system shall be able to process user queries in a shortest time possible, bringing up-to-date and saving records shall be fast Login, logout process shall be done quickly
Security	A system shall enable authentication of users within an encrypted password, it should remember the password and username of the user
Usability	A system shall be user friendly so that it can be easily used by all types of users
Robustness	Shall be able to recover from failure in case of connection problems
Availability	Shall be available when needed
Language	Shall be available in both Swahili and English

3.2.5 Architectural Design

i. Web-based System/ portal

The proposed web portal is designed to be used by all types of users mainly botanists, researchers, vendors, Arusha City Council representatives, any other type of user and an administrator to perform administrative activities. The system keeps information (taxonomy) of the invaluable species of ornamental plants and flowers available for sale by vendors in Arusha City which include; English name, Botanical name, Family name, Native or origin, Vernacular name, Trade name, Description by size, shape, color, genera, image, uses of the each species in terms of (medicinal or herbal, edible or for food, poisonous and ornamental) and also Conservation in terms of quantity (Extinct in the wild, Extinct, Critically Endangered, Endangered, Least Concern Vulnerable, Nearly Threatened, Data Deficient and Not Evaluated). Additionally, the profile of the vendors selling the ornamental plants and flowers together with their methods of operation, challenges they face, the locations of the vendors are uploaded in a centralized database. The users can be able to search for information on the invaluable species of ornamental plants and flowers in Arusha City, for example, botanists, researchers can get the scientific names, family names, trade names and vernacular names of the ornamental plants and flowers with the corresponding images of the specific ornamental plant and flower together with their detailed descriptions. Additionally, the user can also select from categories on the main menu and perform some visualization. The administrator can upload information of the various species of ornamental plants and flowers as shown in

Appendix 4, will also be able to manage user accounts and also carry out registration of vendors selling the ornamental plants and flowers in Arusha City, the administrator can perform visualization on the various species of ornamental plants and flowers. The vendors can advertise as shown in Appendix 6 their products on the portal as well and users interested in their products can place their orders as shown in Appendix 7 on the type of products (ornamental plants and flowers) vendors are selling and also get their location. Vendors can also communicate amongst themselves and also communicate with other users. All users have different user views.

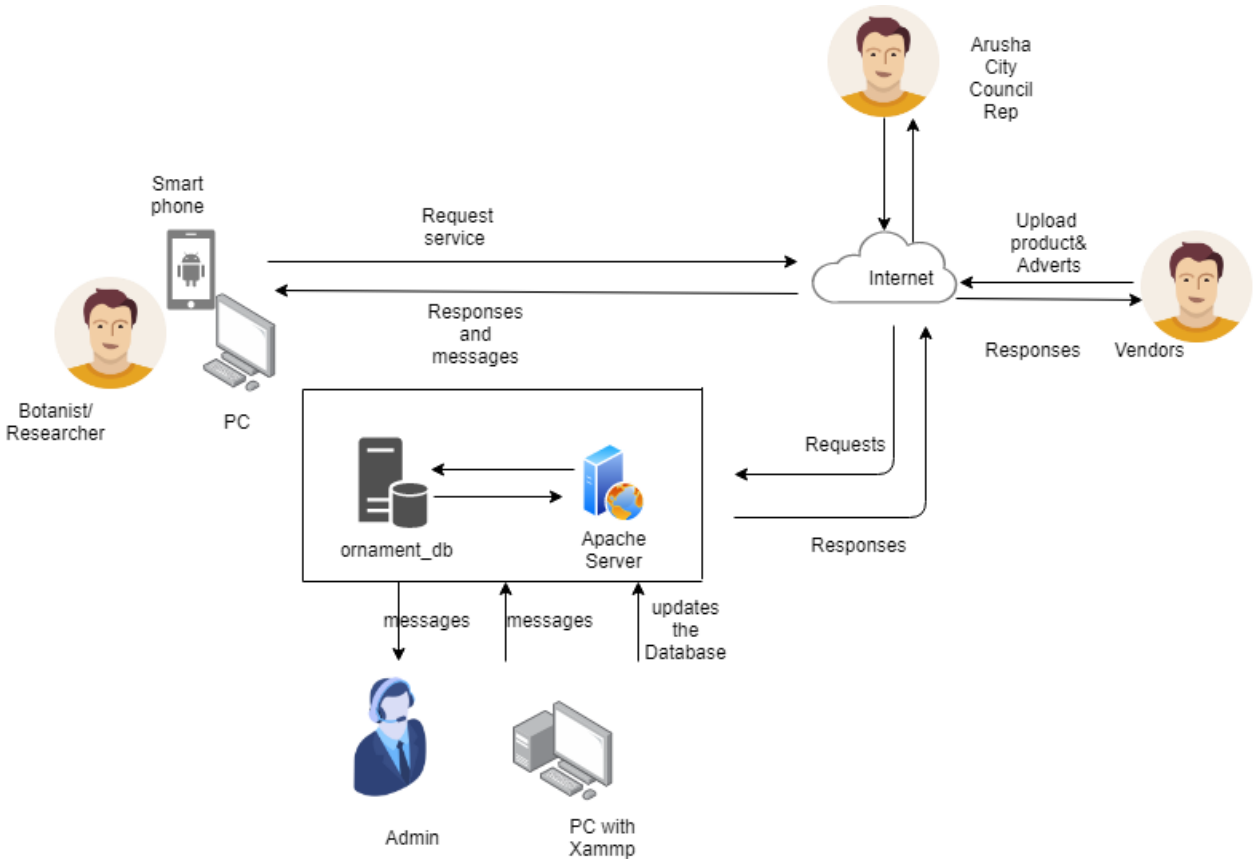

Figure 3: Conceptual Frame Work for the Proposed System

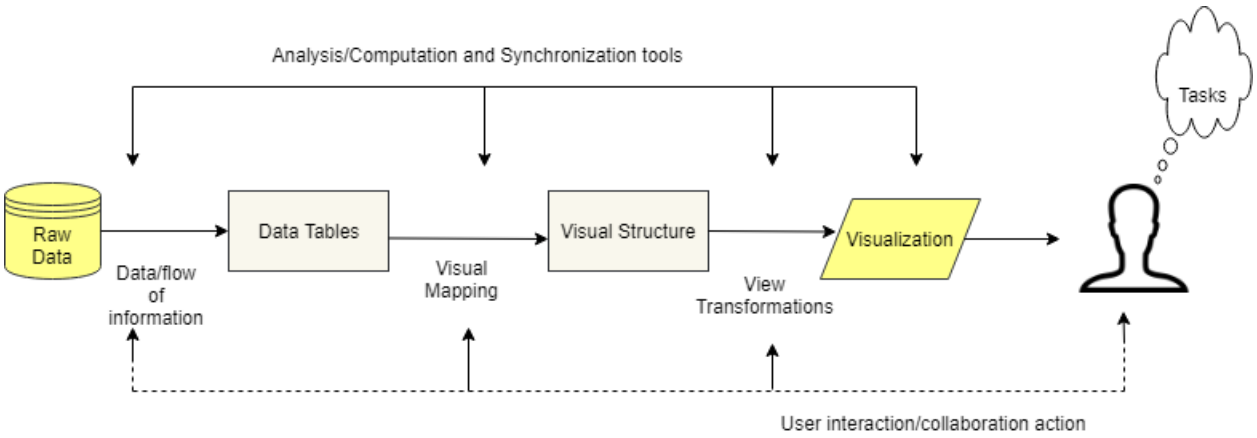

Figure 4: Conceptual Framework for Visualization of Ornamental Plants and Flowers

ii. Context Diagram

A context diagram also known as DFD level 0 describes the relationship amongst the system and its environment (user and related system) showing the interaction of the existing entities with system process. It is the diagram that represents a high-level or top-level view of a system containing one process or process 0 that generalizes the overall function of the whole system in relation to external entities.

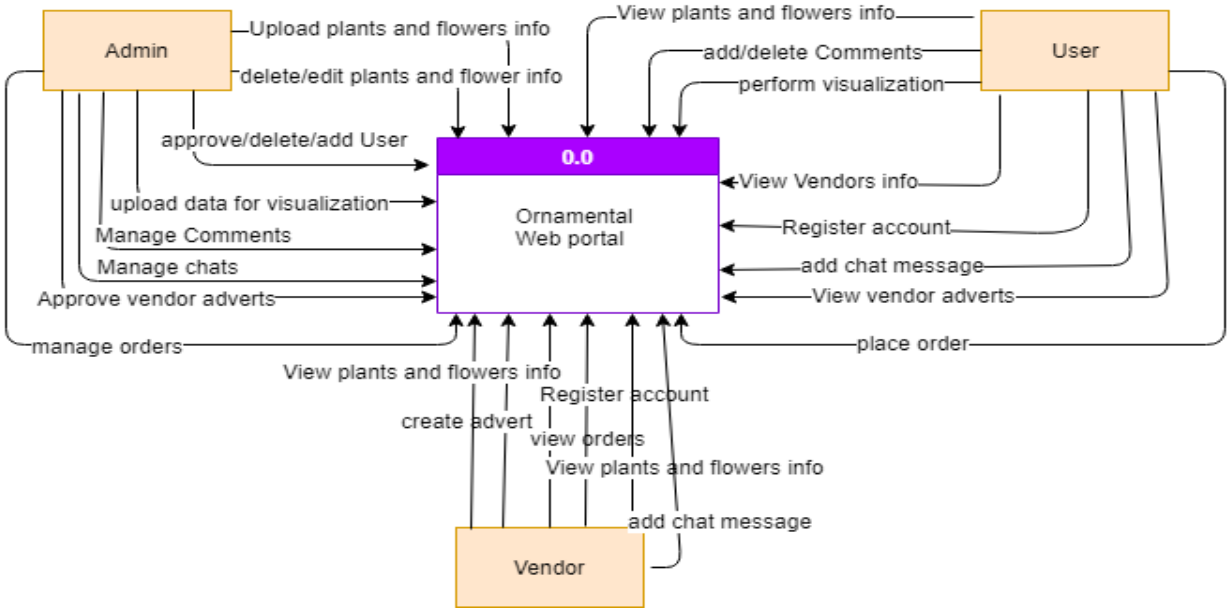

Figure 5: Contextual Diagram

iii. Data Base Design

Database design involves the process of organizing data in accordance to a database model. It is a process of identifying entities, relationship of entities and attributes of all entities. The database designer determines what information to be stored and how the information should relate to each other. In other words, database design is the classification of data and establishing their interrelationships.

iv. Entity Relation Diagram (ERD)

It is a graphical representation of database system which represents the interrelationships among data that are expected to be stored into the database such as people, places, objects or events within that system

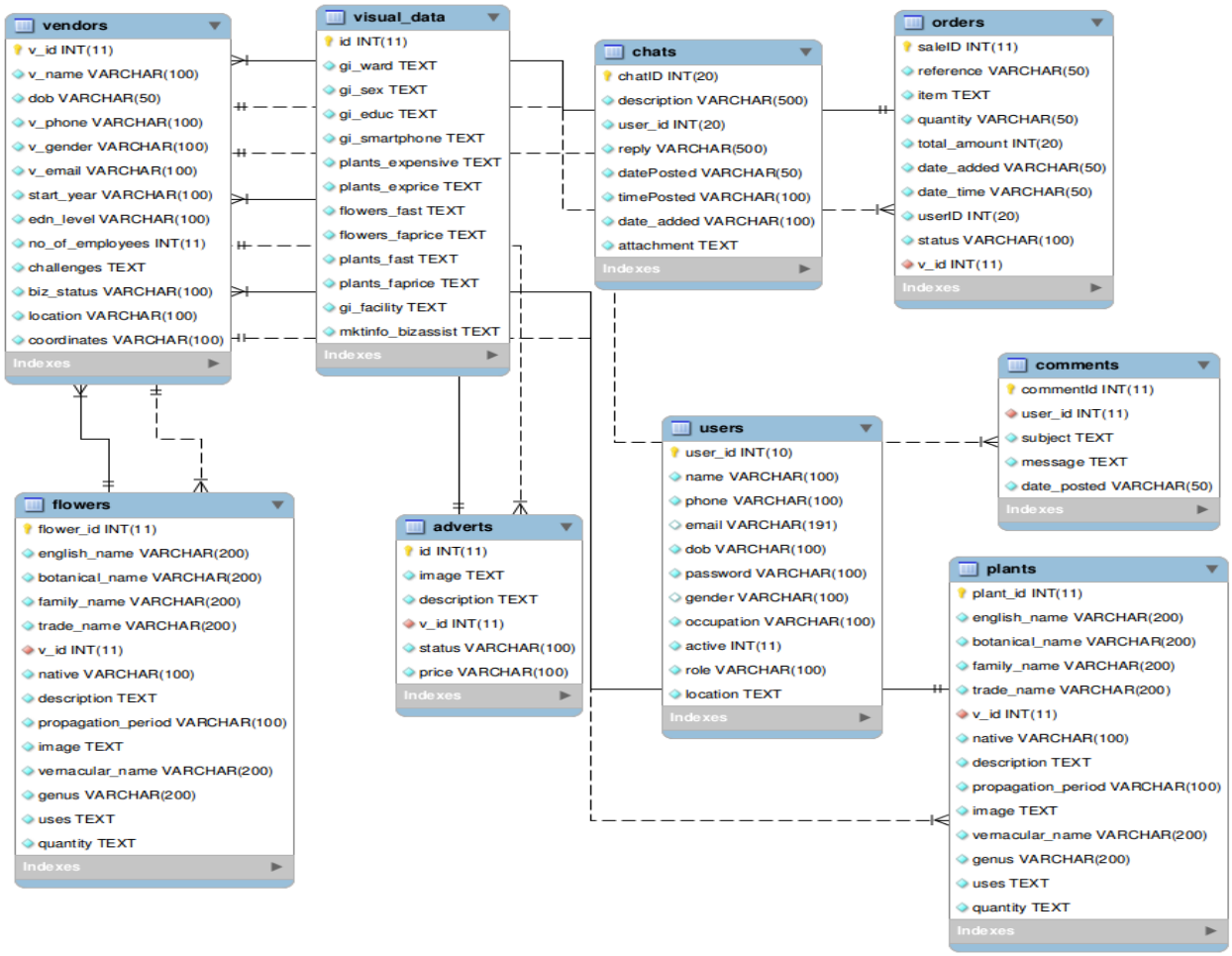

Figure 6: Entity Relation Diagram (ERD)

The Entities extracted from the above ERD are User, Order, Plant, Flower, Vendor, Chat, Comment, Visual data and Advert.

The relational schemas of the ERD are:

i. User (userID, DOB, name, gender, phone, occupation, email, password, role, location)
ii. Order (SaleID, reference, item, quantity, total_amount, date_added, date_time, userID, status, v_id)
iii. Plant (plant_id, english_name, family_name, vanacular_name, trade_name, botanical_name, image, propagation_period, description, native_name, order, genus, uses, quantity, v_id)
iv. Flower (flower_id, english_name, family_name, vanacular_name, trade_name, botanical_name, image, propagation_period, description, native_name, order, genus, uses, quantity, v_id)
v. Vendor (v_id, v_name, v_gender, location, biz_status, dob, challenges,no_of_employees, edn_level, v_phone, start_year, v_email)
vi. Chat (chatID, description, userID, reply, datePosted, timePosted, date_added, attachment)
vii. dvert (id, image, description, v_id, status, price)
viii. Comment (commentId, userID, subject, message, date_posted)
ix. Visual data (id, gi_ward, gi_sex, gi_educ, gi_smartphone, plants_expensive, plants _exprice, flowers_fast, flowers_faexp, plants_fast, gi_facility, mktinfo_bizzassist)

v. Use Case Diagram

Use Case Diagram depicts the interaction of users and the system. It describes what actions or processes a user can perform in the system. In Use Case Diagrams, Actions are called Use case.

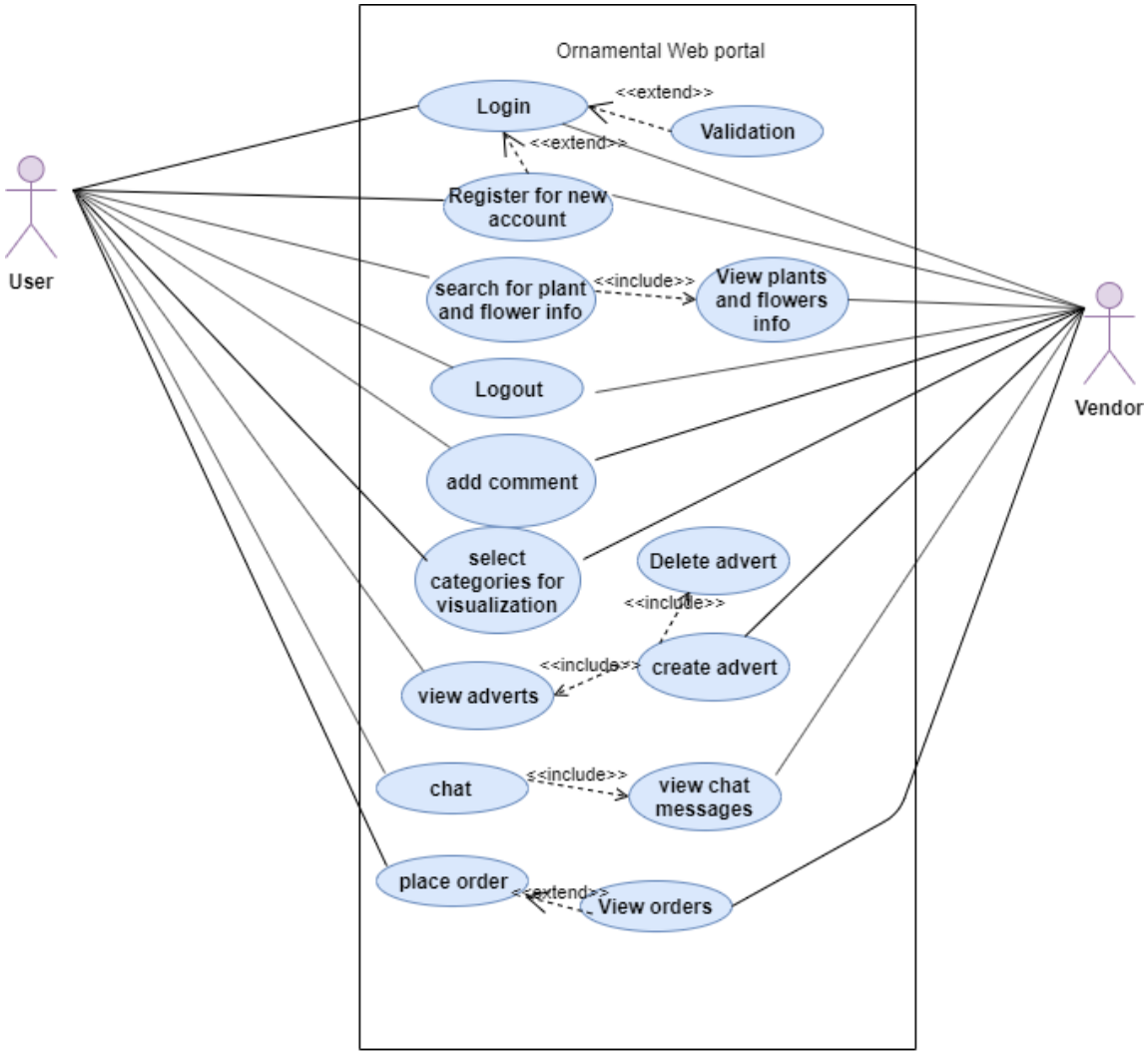

Figure 7: Use Case Diagram for the Proposed System Showing User and Vendor

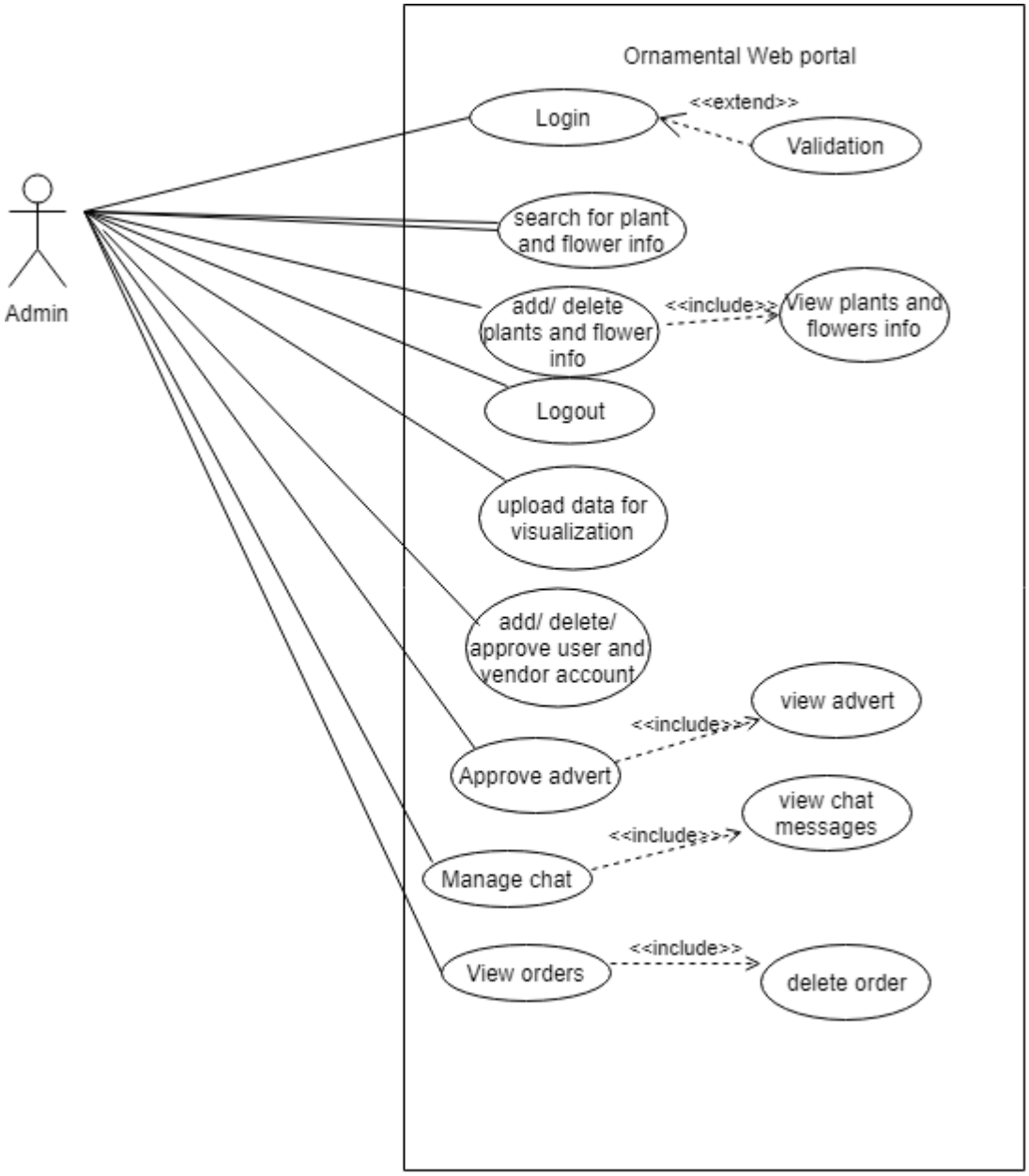

Figure 8: Use Case Diagram Showing Admin

Cases and External Entities are called Actors. Actors of the proposed system solution are Vendor, User (Arusha City Council Representative, Researcher and Botanist) and System Administrator.

The Use cases; Login, Register for a new account, search for plant and flower info, view plants and flowers info, add comment, Logout, select categories for visualization, view advert, create advert, chat, add/delete plants and flower info, upload data for visualization, Approve advert, manage chat, view chat messages, view orders, delete order, add/delete/approve user and vendor account and place order.

3.2.6 Development and Implementation of the Proposed Solution

3.2.7 System Development Tools and Technologies

These are client-side scripting languages. The source code written with client-side languages is executed within the browsers. The source code execution process takes place within the end users' computers. Although the source code is executed within the browser, they are transferred from the web server to end users' computers through the internet.

i. Hypertext Markup Language (HTML)

The Hypertext Markup Language (HTML) is basically for formatting and displaying data. It is the most frequently used language to develop websites. The HTML tags have pretty intuitive names namely header tags (such as h1, h2, h3…), paragraph tags (My paragraph), image tags (<img src="" alt=""> </img>), anchor tags (a href="" target=""> Home) and among others. HTML was used in implementing the front-end of the application especially in the design of the interfaces which enable users to interact with the system. The HTML offers the simple structure of sites, which is greater and improved by other technologies like CSS and JavaScript and it is fundamentally used for interface design. Hyper Text Markup Language was preferably used since it is easy to learn and incorporate with other languages, supports all browsers and most search engine friendly.

ii. Cascading Style Sheet (CSS)

The Cascading Style Sheet (CSS) is a programming language particularly directing on how the HTML elements of a website should actually look on the user interface page. The HTML provides the raw tools needed to structure content on a website. The CSS, however, helps to style this content so it appears to the user the way it was projected to be seen. In simple terms, CSS is the makeup of the page and these languages are kept separate to ensure websites are built correctly before they are re-formatted. This was used in the overall design of backgrounds and styling of the HTML interfaces so that they look attractive to the clients since it is among the characteristics of a good web-based system. It included styling the background images, colors, headings, sections, headers, footers among others which are part of the interface design. In order to link a CSS file to an HTML page, the "link" was used in the "head" tag of the page.

For responsiveness of the webpage, “bootstrap.min.css” was used in the design to guarantee that the portal is available in all devices regardless of the magnitude.

This is a library that works with a JavaScript library called “bootstrap.min.js” to enhance the appearance and controlling the display of the web page. Font-awesome CSS was also used to beautify the icons and this was achieved by using the online Code Distribution Network (CDN) link “*https://cdnjs.cloudflare.com/ajax/libs/font-awesome/4.7.0/css/font-awesome.min.css*” which is free for use. This library enables easy use of relevant icons to keep the user updated with what he or she is likely to view when the link is clicked. For example (<i class=”fa fa-user”> </i>) displays the icon of the user keeping the information displayed on the web page relevant to the public.

iii. BOOTSTRAP

Bootstrap modal elements were used to capture data without hiding the web page content. This was achieved with the help of popup window that show up whenever the user clicks either the link or button and this ensures consistency of the web pages. Bootstrap is a freely available open-source framework technology used for developing web applications. It consists of HTML and CSS form templates, buttons, navigation, JavaScript extensions and other interface design components.

iv. JAVASCRIPT

JavaScript programming language was used to alter website content and style it to perform in different ways in response to a user's activities. Common uses for JavaScript include confirmation boxes, dismissible alerts, notification alerts, adding new identities to existing information as well as controlling the behavior of the entire web page elements.

JavaScript was also used in validation of the system forms' data inputs to see if they will be rejected let us say for example whenever the user enters incorrect username or password, the JavaScript functions should alert the user about such mistake or error in turn helps in managing the system status and performance.

Angular JavaScript library “angular.min.js” was used to validate the form interfaces while the user is typing. It synchronizes the form input field value with a predetermined regular expression, spans the error in red if the input is not matching the format and eventually disables

the submit button until the input is correct. This ensures that the data that is posted by the form is valid and does not need back-end validation thus reducing on the time complexity of form processing.

Asynchronous JavaScript and XML (AJAX) was used to load content of the web pages such as chat room dynamically and automatically refreshing in the background. It was also used in the live table edit of the data within the tables that display data, where on “blur” event, the content in the table field (“<td>”) becomes editable and after removing the cursor it automatically saves to the database.

Canvas JavaScript was used for data visualization where the file (“canvasjs.min.js”), a JavaScript library for plotting graphs was used alongside HTML and Hypertext Preprocessor (PHP) to display content dynamically from the database. The data is first fetched from the database depending on the query, then PHP creates the array and then Canvas JavaScript converts the PHP data array to JavaScript Object Notation (JSON) for easy plotting. The generated graphical image can easily be hovered on to view the details with the provision of “Print”, “Save as JPEG”, and “Save as PNG”.

JavaScript library for sliding the images on the web page was also used to enhance the appearance and availing more pictures of the ornamental plants and flowers alongside their description. The two library files “jssor.slider-23.1.6.mini.js” and “jquery-1.11.3.min.js” were includes in the “head” of the page to enable the slider of the images to work.

Google Translate plugin was also used to enable translation of the web page to the preferred language. This makes it simple for the web portal content to be easily understood anytime anywhere without fail.

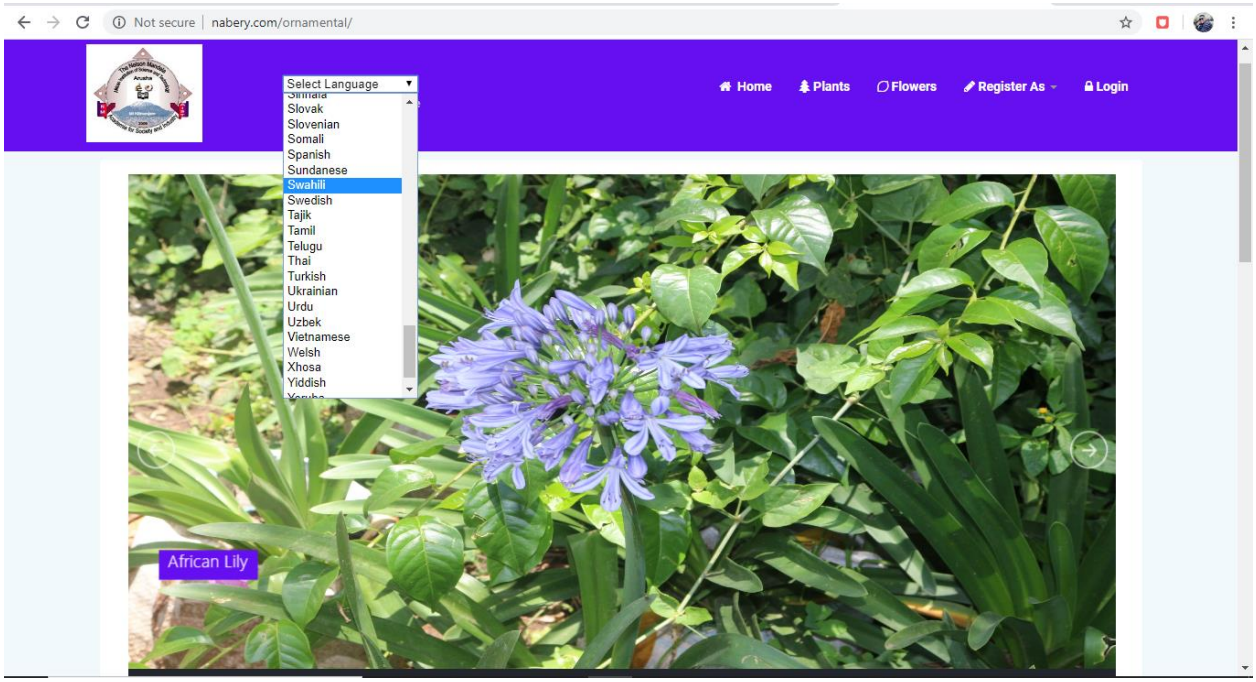

Figure 9: Screenshot for Google Language Translator Plugin

3.2.8 Server-side Languages

They are used to develop interactive web-sites which provide dynamic web contents from databases to users and vice-versa. Currently, a lot of scripting languages exist for server-side, to mention few; Nodes.js, PHP, Ruby on Rails, Django, ASP.NET, and Java. Each server-side language has its advantages and disadvantages which makes difficulties for programmers to choose a right server-side language for developing a dynamic website projects (Crawford & Hussain, 2017).

In this study PHP was used in development of the proposed system solution. PHP is used in developing the dynamic web system contents.

PHP is one among the mostly used server-side scripting language employed in web-based systems implementation. A number of web-based systems are using PHP and therefore easily to get support of its developers worldwide.

i. Hypertext Preprocessor (PHP)

The Hypertext Preprocessor (PHP) is a dominant tool for creation of dynamic and collaborating web pages, a server scripting language that is a broadly used, open source, and resourceful. In

the development of the backend of the system, PHP 7 was used and it required use of functions, database queries as well as data structures such as arrays.

The PHP was used to handle form data for example when the user is registering, the form method “POST” is used to capture data and process it with the database functions for storage. This involves the use of SQL scripts in order to store and get data from the database.

In order for the system to work, the local server “Apache” has to be running alongside “MySQL” which opens the database connections via port “3306”. This is accomplished by first launching “Xampp Control Panel” and ensuring that all the services are running.

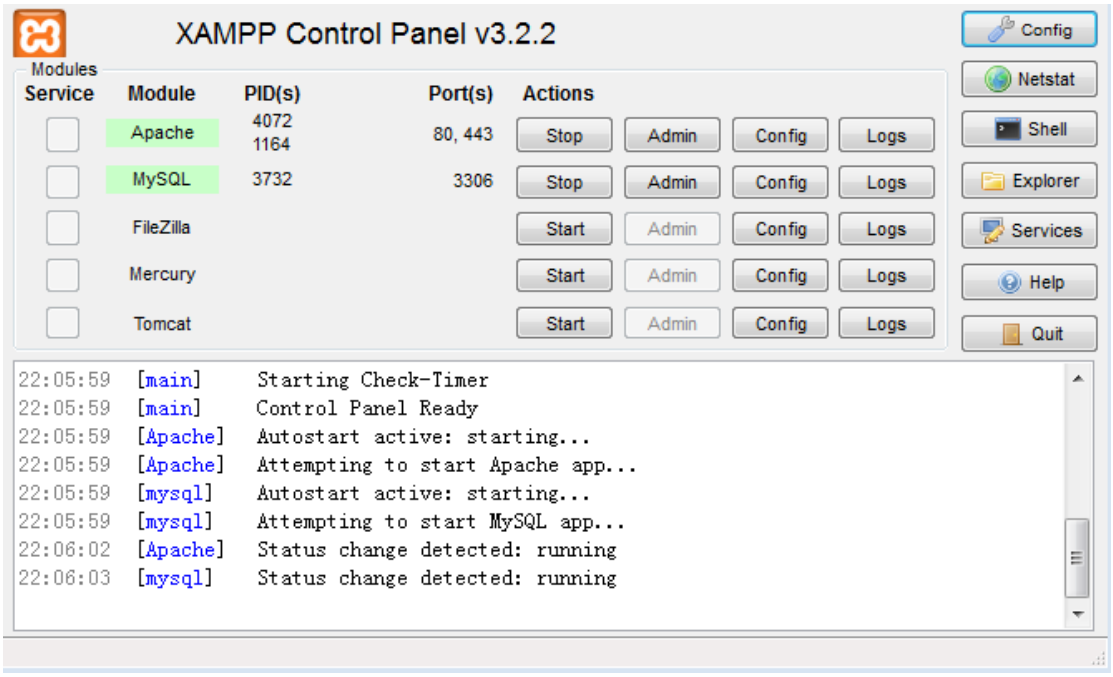

Figure 10: Local Server Showing Apache and MySQL Services Running

The PHP Data Object (PDO) was used for database queries since it creates instances of the database connection and ensures persistent connections enabling the server to execute queries in a very little time. This enhances the performance of the web pages with quick response to the users' requests**.** For example, the script in Fig. 11 connects to the system database “ornament_db” with user “root”, server “localhost” and no password**.**

```
$dbh = new PDO('mysql:host=localhost; dbname=ornamental_db', 'root', '', array(PDO::ATTR_PERSISTENT => true));
```

Figure 11: Screenshot of PHP PDO

To ensure that all the pages are connected to the database, the file “config.inc” located in “C:\xampp\htdocs\ornamental\root\” is included on top of every page with a simple script (<?php require_once(‘root/config.inc’) ;?>).

The PHP session functions were used to control the user views and what kind of information they access. Despite the login interface being the same, the system automatically checks the user type and redirects to the correct web page which is determined by the session variables that are set when the user logins. The session automatically expires when the user logs out.

With the help of PHP arrays, the upload of the dataset Comma Separated Values (CSV) file was simplified with the “array_map” function. This function inside the file “update.php” reads the file called “visual_data.csv” located in the system folder “C:\xampp\htdocs\ornamental\”, gets contents from the excel sheet by iterating through all the rows and then inserts it to the database for visualization as elaborated in Fig. 12.

```php
<?php
require_once 'root/config.inc'; // call the connection file
$dbh->query("DELETE FROM visual_data"); // first delete all the values before inserting new values
$csv = array_map('str_getcsv', file('visual_data.csv')); // read the file(visual_data.csv) and get the array values
$arr = array();
for($i = 0;$i < sizeof($csv);$i++){ // loop as you get the values
    array_push($arr, array('gi_ward' => $csv[$i][0],'gi_sex' => $csv[$i][1],
    'gi_educ'=> $csv[$i][2],'gi_smartphone'=>$csv[$i][3],'plants_expensive'=> $csv[$i][4],'plants_exprice'=>$csv[$i][5],
    'flowers_fast'=> $csv[$i][6],'flowers_faprice'=>$csv[$i][7],'plants_fast'=> $csv[$i][8],'plants_faprice'=>$csv[$i][9],
    'gi_facility'=> $csv[$i][10],'mktinfo_bizassist'=>$csv[$i][11]));
}
$counter = 0;// initialize the counter
foreach($arr as $k => $value){
    // loop through the associative array as you insert in the table visual_data
    $dbh->query("INSERT INTO visual_data VALUES('','".$value['gi_ward']."','".$value['gi_sex']."','".$value['gi_educ']."',
    '".$value['gi_smartphone']."','".$value['plants_expensive']."','".$value['plants_exprice']."','".$value['flowers_fast']."',
    '".$value['flowers_faprice']."','".$value['plants_fast']."','".$value['plants_faprice']."',
    '".$value['gi_facility']."','".$value['mktinfo_bizassist']."') ");
    $counter++; //increment the counter for each inserted record
}
?>
```

Figure 12: Reading and Uploading Dataset File for Visualization

Table 4: Comparison of PHP Versus Other Server-side Languages

Language	Ease of getting started setting up local environment	Integration with Database	Popularity
PHP	Simplest (requires marginal work to build a new PHP file and view it on the local server)	Takes the greatest support upon initial setup as it incorporates easily with Oracle, MongoDB PostgreSQL, MySQL, and upon installation	11.7%
Django	Complicated as setting up the initial hostname, port number and URL patterns, produce additional steps that can be puzzling and hard to comprehend	Depends on driver's support added in Python language. Supports most of the database types however may not be clear on how to utilize and may be hard to find.	0.1%
Ruby on Rails	Although easy to create a new project and run on a local server, it is however difficult to set up	Receives database support from RubyGem packages since support for databases is not available.	0.3%
Node.js	Comprise of extra challenging syntax that may not be fairly clear to a beginner	Does not have support upon initial setup for any Database, however, depends/relies on packages	0.24%

Crawford and Hussain (2017) and Alfred and Kaijage (2019)

ii. Data Base Implementation

The ornamental web system database was developed using My Structured Query Language (MySQL). MySQL is compatible with various operating systems platforms like i5/OS, BSDi, Symbian, OS/2 Warp, eComStation, IRIX, SCO OpenServer OpenBSD, Microsoft Windows, OpenSolaris, Novell NetWare, Linux, SCO UnixWare, SunOS, AIX, Solaris, FreeBSD, Mac OS X, Tru64, HP-UX, and Sanos NetBSD QNX. From this therefore, MySQL was chosen in

developing the systems' database with guarantee that the system will run in different Operating System platforms. It can a variety of information and allow retrieving online (Alfred & Kaijage, 2019).

MySQL was also chosen as a database management system because it is an open source, scalable and robust. MySQL is used for a varied variety of purposes, including e-commerce, logging applications and data warehousing. However, the most common use of MySQL is for web-based applications. In order to connect the system to the database, the local server has to running together with the database connection script which is located in the folder inside the folder *"C\xampp\htdocs\ornamental\root\config.inc".*

3.2.9 Source Code Editors

A source code editor is a text editor program designed purposefully to edit the source code of computer programs. It can be either a standalone program or application such as Notepad++, Visual Studio Code to mention a few. Source code editors are very important programming tools because the basic task of computer programmers is to write and edit code. For the study, we used Visual Studio Code as it has many advantages such as; it's IntelliSense for programming language (code editing features: code hinting, parameter info, code completion, quick info, content assist, and code completion). Additionally, its IntelliSense also provides JavaScript, JSON, TypeScript, CSS, HTML, Sass and Less out of the box. Also allows adding IntelliSense extension for other languages that are not supported by default.

3.2.10 Other Requirements

i. Internet connection; the web-based system needs internet connection to be accessible.
ii. Web browser; Google Chrome, Mozilla Firefox, Torch and Internet Explorer.
iii. Operating system; Web-based system operates in Windows 7 and onward versions, Mac OS and free Open Source Operating systems such as Ubuntu.
iv. Hardware; Smartphones, tablets and personal computers.

3.2.11 Assumptions and Dependencies

It is assumed that Users (Researchers, Botanists, and Arusha City Council Representatives), and Vendors have access to a smartphone, personal computers

i. Vendors have access and are able to pay charges for internet
ii. The faultless of the system depends on the correct operation between PHP and MySQL with the web server in which the system runs.
iii. Frequent availability of the system depends on the hosting webserver to be running most of the time without failure

3.3 Summary

This chapter presented the materials and methods involved in this study by describing the case study area, data collection methods and analysis. In addition, it explored more on both functional and non-functional requirements needed for the development of the web portal that will help in providing information about the various invaluable species of ornamental plants and flowers in Arusha City Council and also act as a marketing tool for the vendors selling these endemic species in Arusha.

Additionally, the chapter described the architectural design of the proposed solution. It also provides the description for the development of the proposed system by discussing technologies used and the reasons to use those technologies instead of others

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

The previous chapter presented the materials and methods used in the study. It also provided details on the study area, sample size and sampling technique, data collection methods and requirements needed for the development of the proposed solution. This chapter presents the results and discussions of the data collected in the study and development of the web portal for ornamental plants and flowers.

4.2 Findings from the Respondents

4.2.1 Demographics of the Respondents

A total of 48 responses were collected from 7 wards (areas with most vendors of ornamental plants and flowers) in Arusha City Council where by 26 (54.2%) where males and 22 (45.8%) where females. This gender balance was important as far as selecting sample was concerned. To meet this gender balance, the researcher was challenged by the number of female vendors where their number was lower as compared to their male counterparts. However, efforts were taken to interview at least many female vendors so as to meet the gender balance.

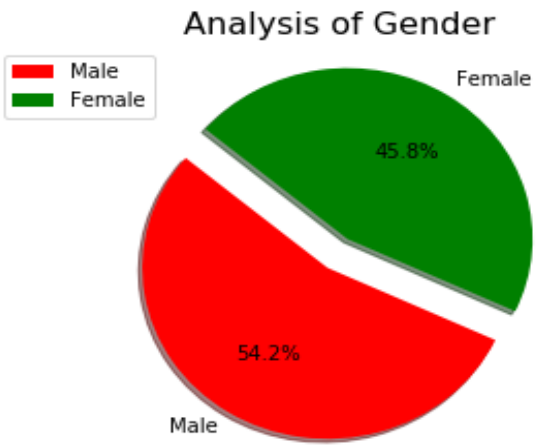

Figure 13: Gender Analysis of Respondents

Moreover, the researcher sampled the respondents based on age group where by 8 were less than 25 years, 16 were between 25 and 35 years, 13 were between 35 and 45, 7 were between 45 and 55 years and 4 above 55 years. This means that most of the vendors are in the youth bracket.

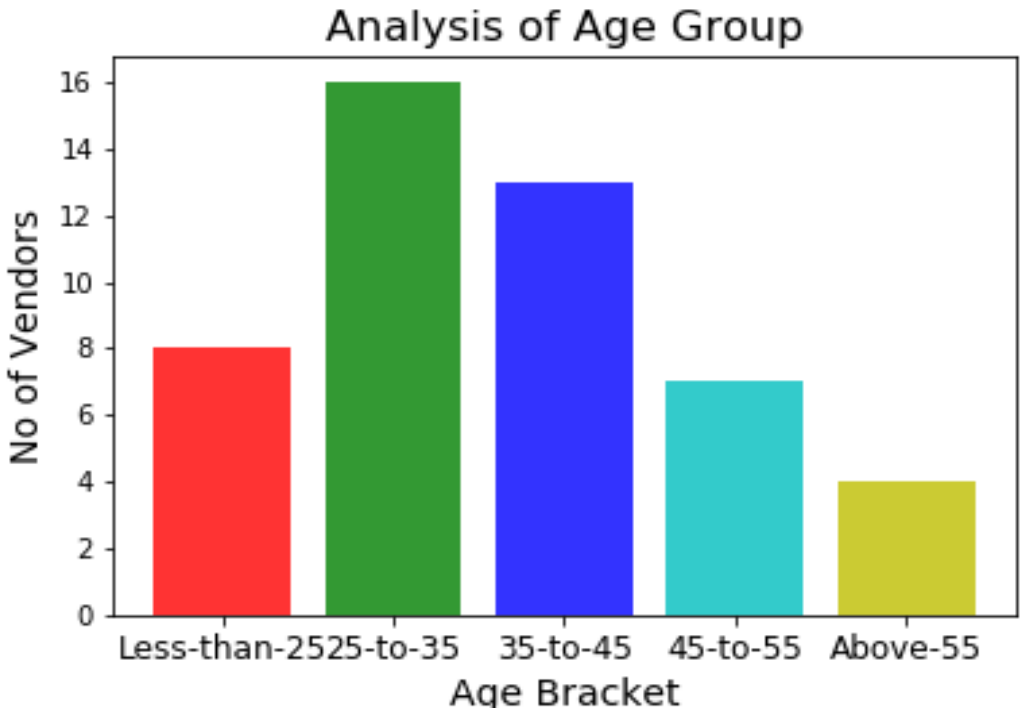

Figure 14: Age Group Analysis of Respondents

The researcher also sampled the respondents by their level of education such as; Illiterate, Primary level, Ordinary level (O' level), Advanced level (A 'level) and Diploma. The 3 were illiterate, 35 of the respondents have primary level, 7 have ordinary level, 1 has Advanced level and 2 have Diploma level.

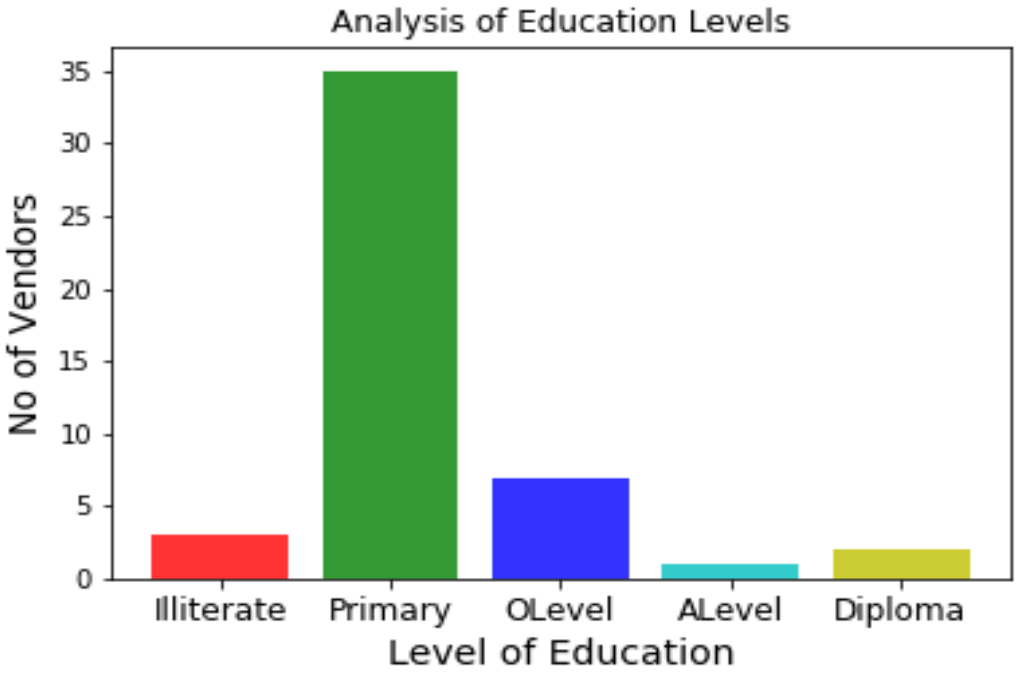

Figure 15: Education Analysis of Respondents

4.2.2 Experience of the Respondents in the Horticulture Industry

To capture the experience of the respondents in the Horticulture industry, the researcher sampled by the year the respondent established the business of selling the ornamental plants and flowers such as; business established less than 5 years, 5 to 10 years and above 10 years. 11 respondents were in business for less than 5 years, 10 have been in business for 5 to 10 years and 27 have been in business for over 10 years.

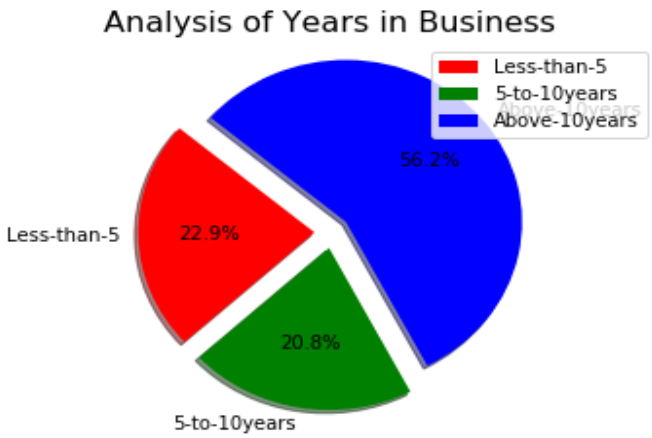

Figure 16: Years in Business by Respondents

4.2.3 Mobile Smart Phones Access

Among the respondents, 28 (58.3%) had access to smart phones and 20 (41.7%) are without smart phones. This therefore meant that majority of the respondents have access to internet and thus can access the developed mobile responsive portal.

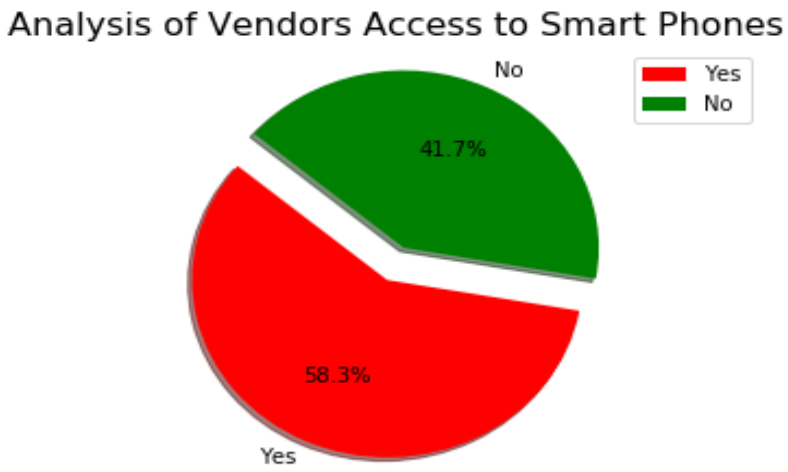

Figure 17: Access to Smart Phones by Respondents

4.2.4 Products Respondents Produce

The researcher also sampled the respondents by the products they produce such as, Herbal, Plants and Flowers. All 48 (38.4%) grow Plants, 48 (38.4%) grow Flowers and only 29 (23.2%) grow Herbals.

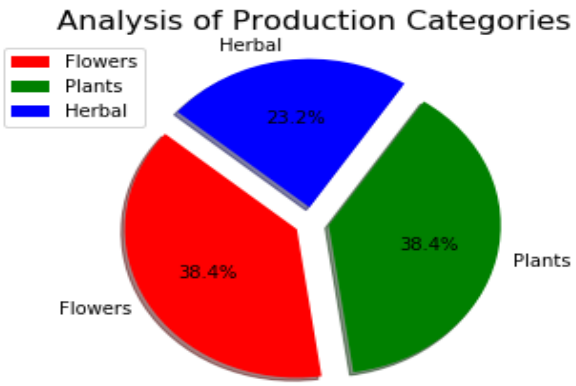

Figure 18: Production Categories

4.2.5 Variety Species of Ornamental Flowers Respondents Produce

Out of 48 respondents, 43 produce African lily, 28 produce Orchid flowers, 33 produce Carnation, 47 produce Rose flowers, 26 produce Tuber Rose flowers, 37 produce Jasmine and 47 produce other types and varieties of Ornamental flowers shown in Fig. 19.

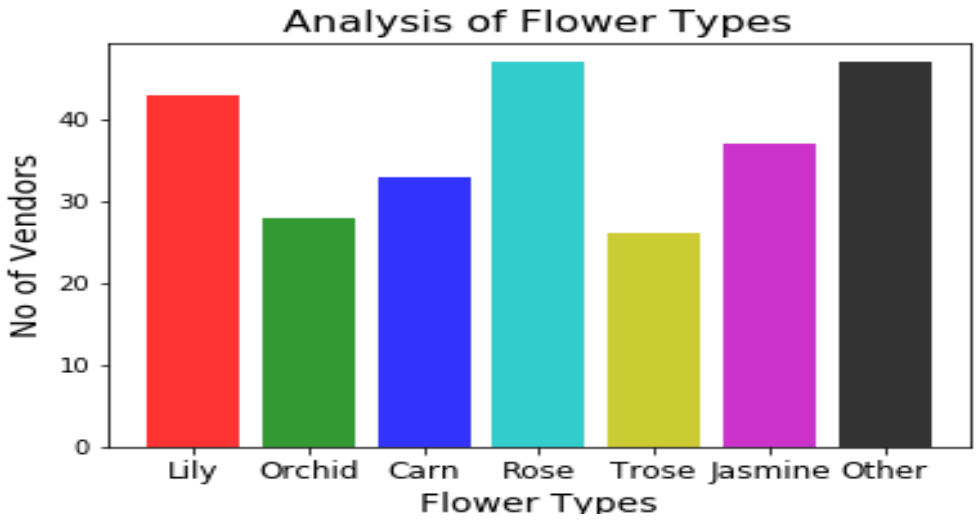

Figure 19: Flower Types Respondents Produce

4.2.6 Variety of Ornamental Plants Respondents Produce

Out of 48 respondents 31 respondents produce Aspograss, 21 produce Golden melaleuca, 27 produce Money plants, 43 produce Ferns and 46 produce other types Ornamental Plants shown in Fig. 20.

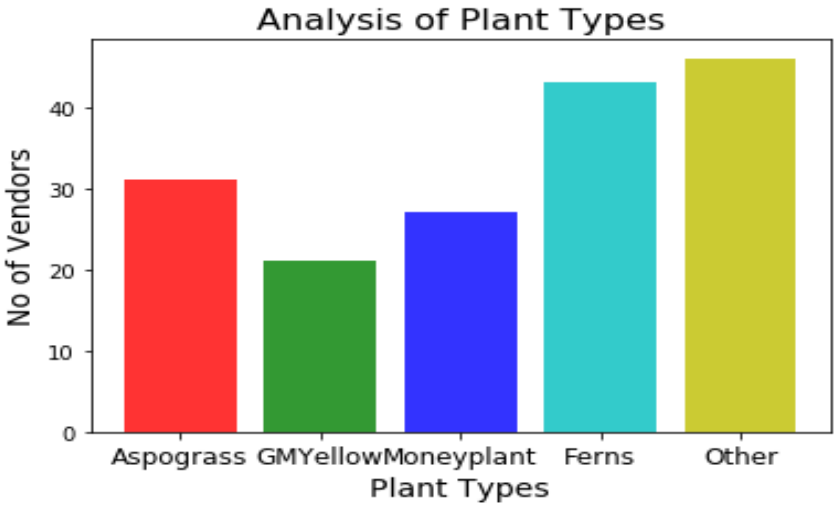

Figure 20: Plant Types Respondents Produce

4.2.7 Assessment of the Respondents Business Ownership Status and Number of Employees in the Business

The study intended to find out how many respondents actually own the business and how many are employed in the business of selling the ornamental plants and flowers. It was found out that 28 (58.3%) said yes, they owned the business and 20 (47.7%) said no they did not own the business.

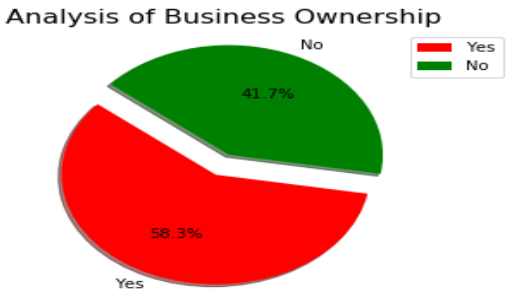

Figure 21: Business Ownership by Respondents

The study also intended to find out how many employees were operating in each business. 13 respondents said they have 1 employee each that is operating the business, 26 respondents said they have 2 employees operating the business, 4 respondents have 3 employees running the business, 2 respondents have 4 employees, also 2 respondents have 5 employees running the operations of the business and only 1 respondent has more than 5 employees operating the business of selling ornamental plants and flowers.

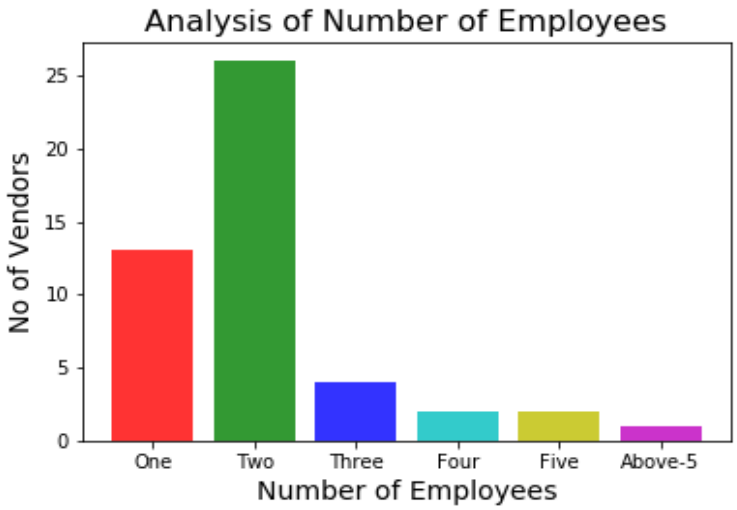

Figure 22: Number of Employees in the Business by Respondents

4.2.8 Assessment of the Challenges Respondents face

The researcher intended to find out the challenges that respondents face such as; Lack of Capital, Business Location has inadequate infrastructure, limited markets of products, pest control, High production and operation costs and other challenges which were recorded. The findings were as, 10 respondents said that the challenge they face is pest control, 12 said they face a challenge of lack of capital, 9 said they face a challenge of business location and inadequate infrastructure, 5 face the challenge of opportunity cost and 37 face a challenge of limited market for their products and 40 had other challenges such as; Lack of space for parking for their customers, water is scarce and the water bill is expensive, theft as their plants and flowers are stolen during the night as there is no security at their business locations, fluctuating prices as the prices of the plants and flowers keep rising and dropping frequently, lack of knowledge about the common and scientific names of the various ornamental plants and flowers as they face confusion when their customers order for a plant or flower using a specific name that the vendor is not aware of, however the study aims to bridge this gap as the web portal will provide all the names (scientific, vernacular, trade and family names) of those flowers and plants with their corresponding images. Additionally, they also face challenges of climate change (Fig. 24) that destroys their products, disturbance from city council for instance passing pipes under their gardens, electricity poles planted on their gardens and electric wires passing over their space of work, the respondents (employees) also said they face a challenge of low salary/underpayment and lastly scarcity of soil and manure among others.

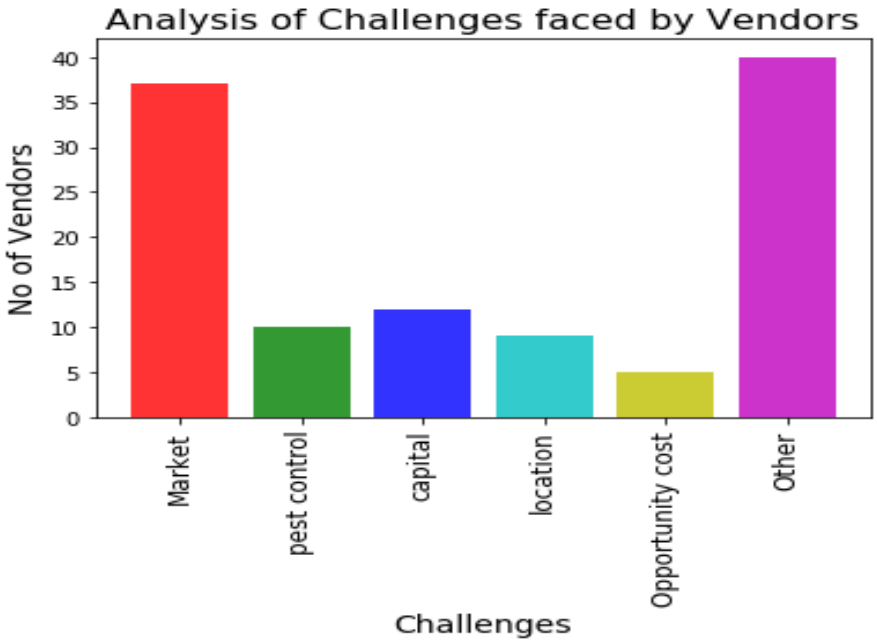

Figure 23: Challenges Faced by Respondents

Figure 24: Climate Change Effects on Flowers and Plants

4.2.9 Assessment of the kind of Assistance Respondents would want to improve their Business

The researcher intended to find out the kind of assistance the respondents would want to improve their business and the findings were as: The 12 (36.4%) said they would need assistance in capital to improve their business, 2 (4.5%) need assistance in improving the infrastructure of their business and 26 (59.1%) said they need assistance in the Market. This supports one of the aims of the study whereby the web portal will act as a marketing tool for the respondents' products in Arusha City Council as it will display the variety ornamental

plants and flowers with the corresponding vendor details with their location so as to easily reach them thus satisfying the need for the web portal development.

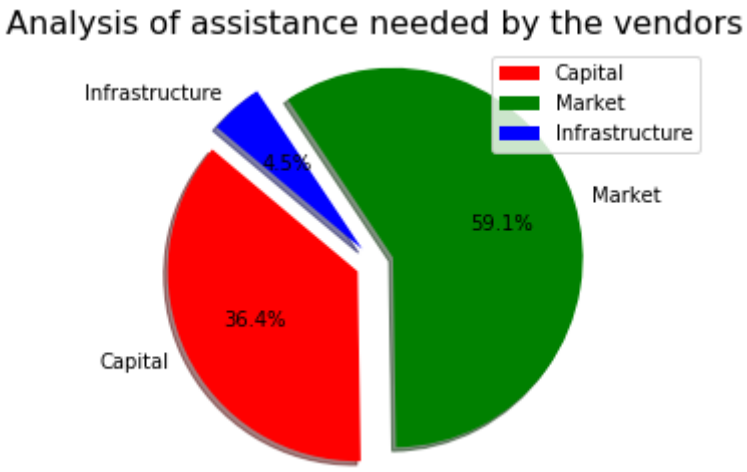

Figure 25: Assistance Needed by Respondents

4.2.10 Assessment of the Kind of Facilities Respondents use to Grow their Products

The researcher sampled the respondents by the kind of facilities they to grow the ornamental plants and flowers which was intended to find out the kind of technology they use to grow their products and this was done by: Natural and conducive climate condition, Greenhouse/controlled environment, special manure/growth agents, Higher efforts in monitoring and No special facility is needed. The findings show that, 1 said he/she has a Green house where he grows his products in a controlled environment, 38 respondents said they grow their products in the natural and conducive environment, 17 said they use a special manure to grow their products, 45 said they do not use any special facility to grow their products and 19 said they employ high efforts in monitoring their products.

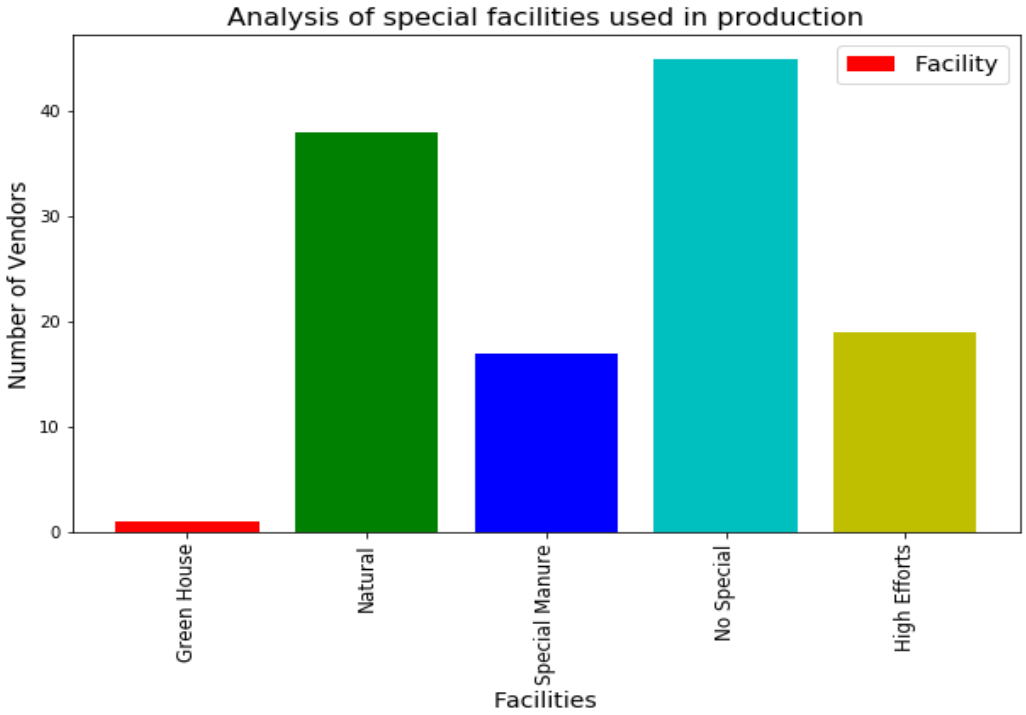

Figure 26: Special Facilities Used by Respondents

4.2.11 Assessment of the Type of Customers the Respondents Serve

The researcher intended to find out the type of customers the respondents serve by; Locals, Local Companies, Foreign Companies and Tourists and the findings were as: The 47 (49.5%) respondents said that most of their clients are local individuals in Tanzania specifically Arusha, 15 (15.8%) said they have foreign companies as their clients, 23 (24.2%) said they serve local companies in the country, 10 (10.5%) said they get tourists as customers however the overall discussion was that the tourists and foreign companies were occasionally unlike for the local individuals and local companies in the country mostly hotels and restaurants.

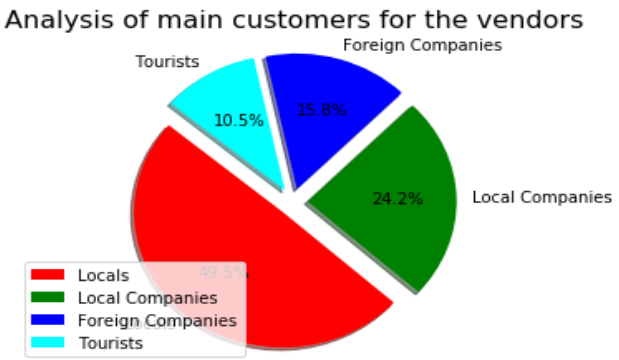

Figure 27: Main Customers for Respondents

4.3 Results and Discussion for the Developed Systems

The main purpose of this section is to understand and report the value of the research results in light of what was previously well-known or current about the vendors experience, knowledge, skills, challenges, location of ornamental plants and flowers to inform new insights, technology to the problem after taking the findings into consideration.

4.3.1 Web portal

A mobile responsive web portal application (Appendix 8) has been developed to be accessed via a web browser online using smartphones, computers and laptops. The software and database are located in a centralized server instead of being installed on the desktop and thus can be accessed over internet.

The mobile responsive web portal application of the proposed system has functionalities such as login, user registration, and vendor registration, manage data, and manage accounts, ornamental plants and flower registration, data visualization, chat, create advert, delete advert. The privileged users of the system are botanists, vendors and database administrator. The database administrator however is able to add or reduce the number of functionalities to be accessed by the botanist.

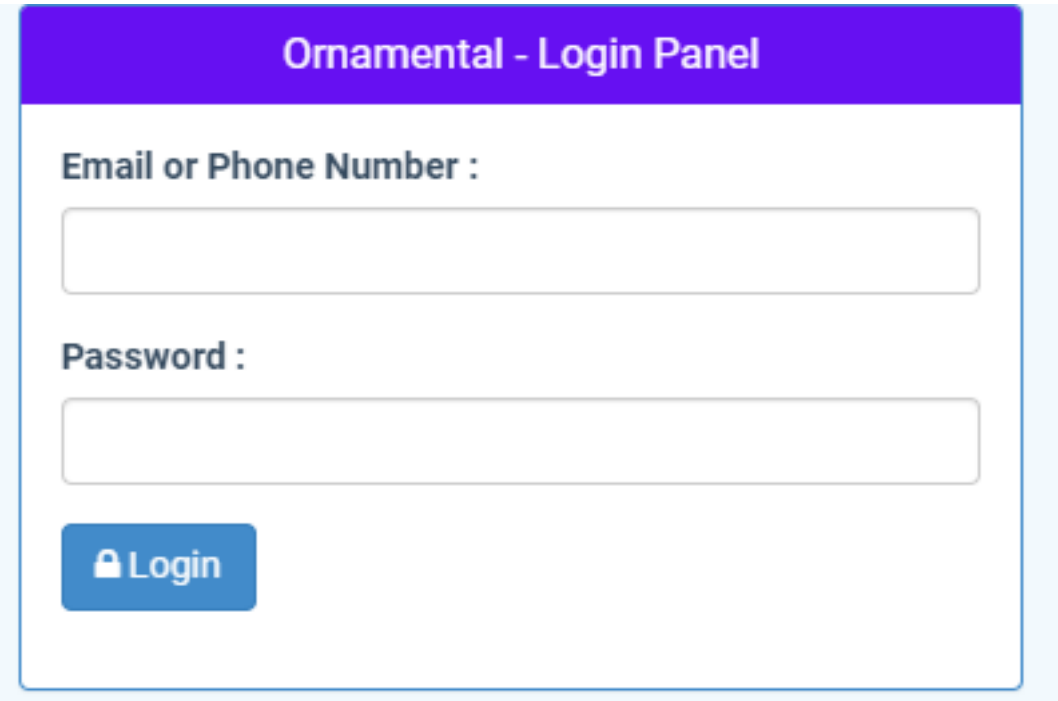

Figure 28: Login Interface for Web Portal Application

i. User registration

The portal allows the registration of users of all types. In this study, one can register as a vendor as shown in Fig. 29 or can register as Botanist, Researcher and Arusha City Council Representative and whose accounts are activated by the administrator before they can be able to login to the portal. The registration process takes place on an easy-to-use web page as the Angular JavaScript library "angular.min.js" validates the form interfaces when the user is typing to confirm the correctness of the registered data by notifying the user in red text as he or she is typing on the bottom pane of the input form. If the record is incorrect, the user is informed on what to do exactly. User details that may be recorded includes: Name, Phone, Email address, Date of birth (DOB), Password, Gender, Occupation, and Location.

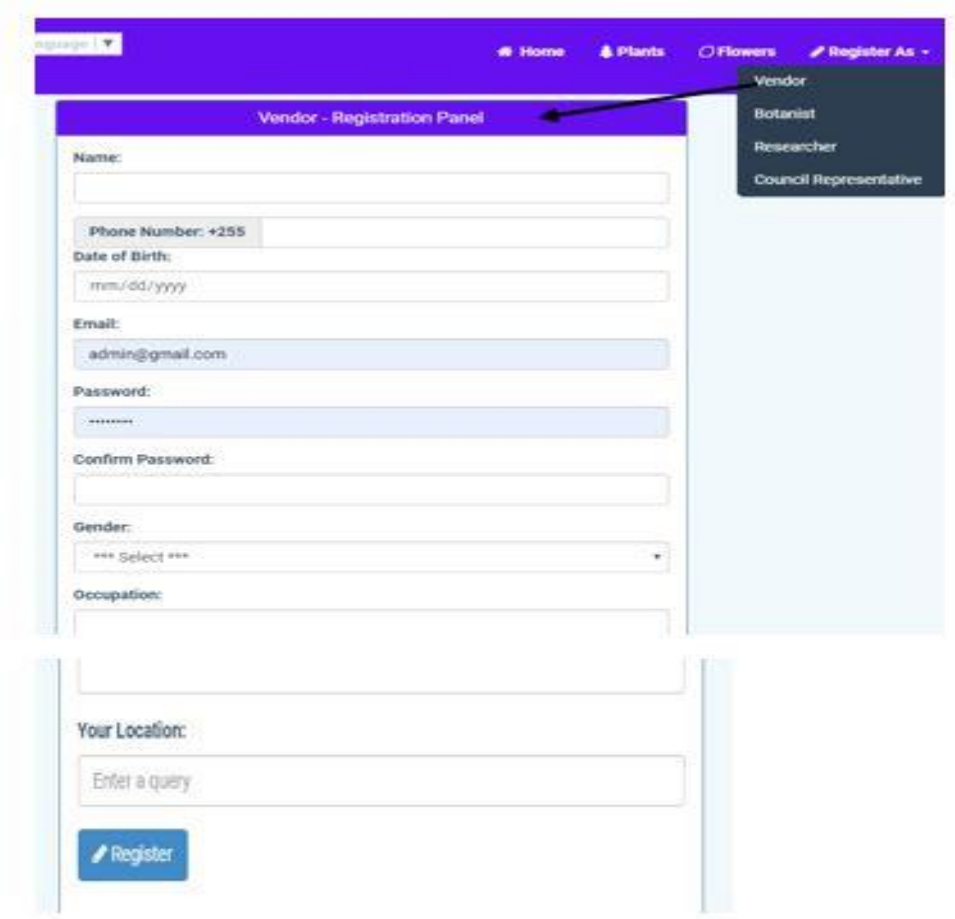

Figure 29: User Registration Page

4.3.2 Other Important Features of the Web portal

i. Manage Accounts

The Manage Accounts is a feature which allows the administrator to activate or approve new user accounts registered in the system as shown in Fig. 30. The administrator can also delete user accounts and also carry out registration of users into the system and manage records for registration as shown in Fig. 30.

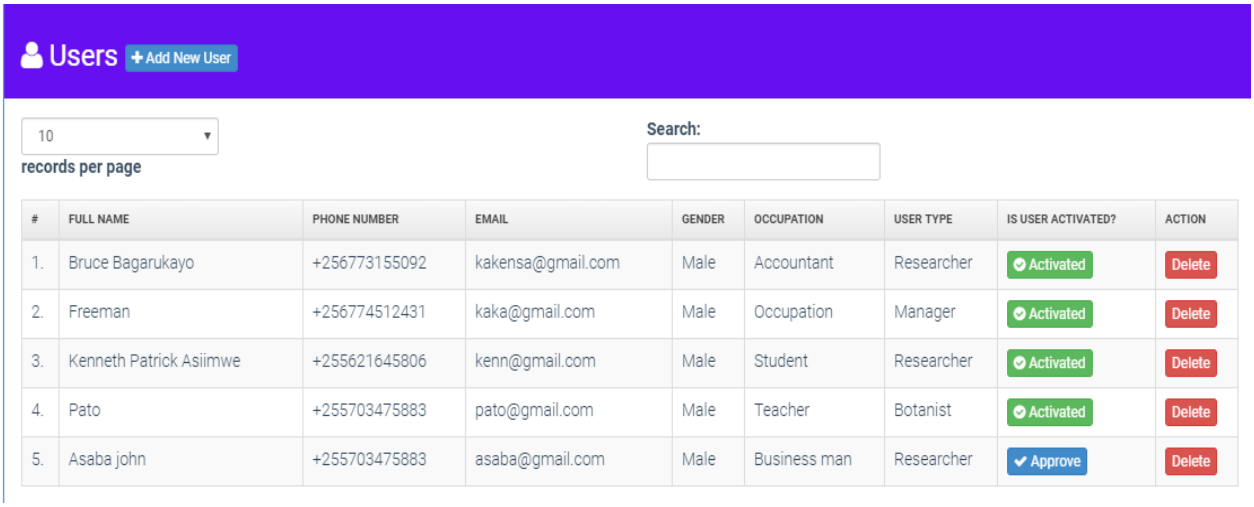

Figure 30: User Management and Registration Page

Other important features to improve usability are search field and filtration field that filter number of records to be displayed on a particular web-page as shown in Fig. 30.

ii. Ornaments

This feature which can only be accessed by the administrator allows the administrator to add information on the species of ornamental plants and flowers, can delete and edit the records. The information of ornamental plants and flowers to be recorded include; English name, Botanical name, Family name, Trade name, Native name, Vernacular name, vendor (s) selling the species, Description by size, color, shape, Propagation period, image of the plant or flower, genus, location (coordinates) of the ornamental plants and flowers, uses in terms of (Medicinal/Herbal, Edible/Food, Poisonous and Ornamental), Conservation in terms of quantity (Extinct in the wild, Extinct, Critically Endangered, Endangered, Least Concern Vulnerable, Nearly Threatened, Data Deficient and Not Evaluated). Figure 31 shows some of the information that has been added of the species.

After adding the above information, all users can be able to view the ornamental plants and flowers with all their information and also be able to view the vendors that have each species and can access vendors' information for example, vendor's name, vendor's number and location of the vendor's business. Additionally, the vendors can create adverts of their variety species of ornamental plants and flowers they are selling and in turn the clients are able to place their orders see.

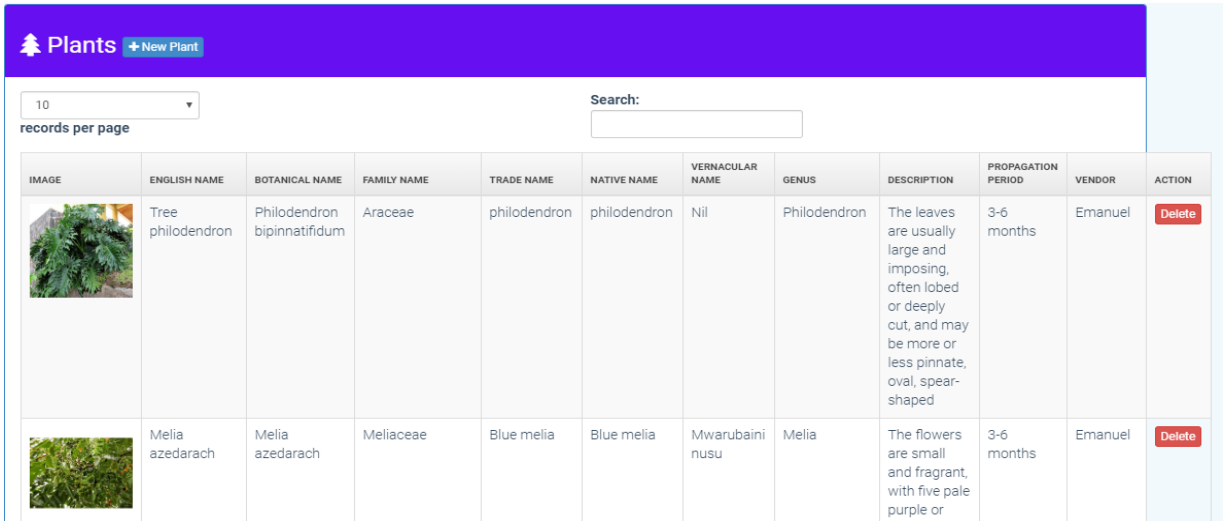

Figure 31: Admin Web Page Showing Added Ornamental Plants

iii. Manage data

The manage data feature allows the administrator to update data for the visualization performed by all users whenever data is changed in the data base as shown in Fig. 32 for process of data visualization). This feature is part of the visualization tool that is embedded on the portal that help users to increase understanding of the data stored in the data base concerning ornamental plants and flowers by vendors in Arusha City Council. The data to be visualized include; expensive plants and flowers with their average prices, fast moving plants and flowers with their average prices, number of vendors in each ward, vendors and gender, vendors with their level of education, number of vendors with access to smart phones.

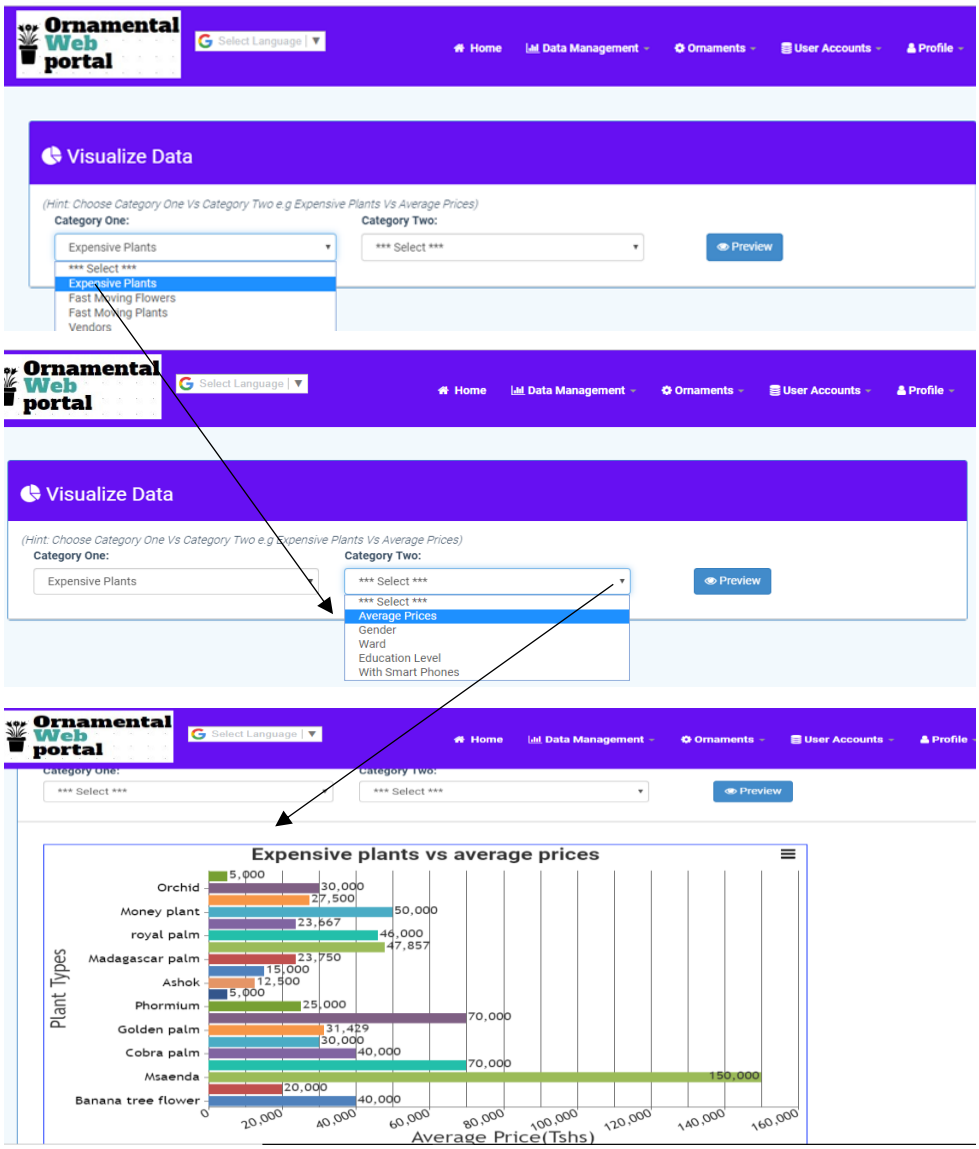

Figure 32: Visualization for Expensive plants vs. Average Prices Web Page

There are many invaluable ornamental plants and flowers available for sale in Arusha City Council by vendors that are not digitized. The proposed web portal will help in digitization of the variety species and will be easily accessible freely via the ornamental web portal. The information to be retrieved on the invaluable species of ornamental plants and flowers include: English name, Botanical name, Family name, Trade name, Native name, Vernacular name, vendor (s) selling the species, Description, Propagation period, image of the plant or flower, genus, order that will be of importance to the researchers and the botanists. Additionally, the portal will also provide visualization for example on the economic status of the horticulture by vendors showing plants and flowers on high demand, most expensive plants and flowers and so on for easy understanding especially the planning authorities such as the Arusha City Council as they are one of the stake holders.

4.4 Validation

Validation is the endorsement by inspection and the delivery of neutral indication that the specific requirements for a particular intended use are satisfied. This ensures that the user needs are met and satisfied. Validation is not only testing and thus requirements should be clearly stated and evidence for the intended use should be provided (Kamalrudin & Sidek, 2015).

For the proposed system, various validation steps were chosen including; unit testing, integration testing, system testing, acceptance testing and regression testing.

4.4.1 Unit Testing

Unit testing is intended for verifying functional behavior of the smallest modules of the system (Dybå & Dingsøyr, 2008). For the proposed system, the units that were tested are; Login, Register for a new account, search for plant and flower info, view plants and flowers info, add comment, Logout, select categories for visualization, view advert, create advert, chat, add/delete plants and flower info, upload data for visualization, Approve advert, manage chat, view chat messages, view orders, delete order, add/delete/approve user and vendor account and place order.

4.4.2 Integration Testing

This testing is intended for verifying the smallest modules validated in the unit testing stage above can work together properly and verify if they are in line with requirements specified in the low-level design (Nidhra, 2012). Various functional units were tested and integrated to verify if they can work together properly. For example, the login page was designed to grant authenticated users' access to enter their specified view or menu to perform different operations as these modules that is, Login and Menu were designed separately but intended to work together as none of the other would work without the other. Therefore, an integration testing was done for all users to ensure that they can login and access their specified menus.

4.4.3 System Testing

System testing is done after the integration testing to verify if the system developed meets the business requirements of the end users. It is the outcome of all integrated and tested functional units that have successfully passed through the integration process. It does not deal with structural features of source codes but the functional features which are visible to end user

(Nidhra, 2012). The system has passed all integration tests done while running on local server. The information submitted into the database from web-based system could be successful retrieved. Table 5 shows a summary of the system testing results.

Table 5: System Testing Results

Requirement	Description	Test Score
Registration (Users, Vendors)	Web portal shall allow registration and login for access of exceptional information and guidance customized for a specific type of users, the administrator will register vendors and also vendors can register and await approval from an administrator, same applies to all new users	Pass
Manage user Accounts	The administrator shall Add, delete users and vendors.	Pass
Add ornamentals (upload images), delete	The administrator shall be able to upload images of the ornamentals and add information of ornamental plants and flowers	Pass
Search	Users and Administrator shall have an advanced search option to ease on information retrieval	Pass
View ornamentals	A system shall be able to display the information of ornamental plants and flowers.	Pass
Visual Data	The administrator shall be able to upload a CSV file in the database for visualization, users should be able to select entries and perform visualization.	Pass
Chat	The system shall provide access to chat rooms for vendors, botanists and other users, store messages in chatrooms, display messages in group chatrooms	Pass
Add/delete Advert	The system shall provide access to the vendors to advertise their products and delete the advert	Pass
Place Order	The system shall allow clients to place order on advertised products by vendors.	Pass

4.4.4 User Acceptance Testing

Acceptance testing is led by anticipated users or customers of the developed software. The aim of acceptance testing is to define whether the software is working properly and meets their core business requirements. Privileged users are allowed to interact with the system functional units to assess their correctness and other performance factors like speed, easiness and responsiveness (Nidhra, 2012). Moreover, questionnaires were distributed to different people with the aim of finding out users' perception and views on the developed system. A total of 48 vendors were introduced to the web portal and given 2 days to use the system and later given the survey questionnaires to fill in the responses on how they feel about the system. The survey responses were computed in a mean score on a five-point scale Likert scale where by (5 = Strongly Agree, 4 = Agree, 3 = Neutral, 2 = Disagree and 1 = Strongly Disagree) as shown in Table 7.

From the study, the mean score for each validated feature was above 3.5 which indicates that the majority of the sampled respondents accepted the system and they expressed their willingness to use the developed system to conduct their business activities. The respondents also recommended that the Arusha City Council representatives should use this web portal to get information on their challenges to make informed decisions.

Table 6: User Acceptance Results

Validation Feature	Respondents					Mean Score
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	
The web portal is easy to use	0	0	2	8	38	4.75
The web portal will impress many vendors to use it as a marketing platform	0	0	2	7	39	4.78
The web portal will help vendors to vie w important information on the variety species of ornamental plants and flowers	0	0	1	11	36	4.73
This application will help City councils in proper planning regarding vendors and conservation of the ornamental plant s and flowers in Aru sha	0	0	2	11	35	4.69
I will recommend this tool to my team/ colleagues	0	0	2	12	34	4.67

4.5 Discussions

The findings of this study show that the majority of the vendors still rely on traditional ways of marketing their products such as direct contact with customers, referrals, sign posts on road reserves and also most information on the ornamental plants and flowers in mainly undocumented and not digitized as botanists, researchers and general public rely heavily on herbariums for access of information on these species of ornamental plants and flowers, stand-alone computers and old technologies (for example DOS for BRAHMS). As the previous different studies also show that small scale farmers lack visibility in the regional and international market which is attributed to inadequate information on markets due to limited access to information.

The study also shows that the vendors are aware of the importance of ICT but however majority of them are not using it for their businesses. Nevertheless, they are willing to adopt to an easy to use developed web portal to carry out their businesses. The study furthermore revealed that there are existing systems used in Tanzania for keeping information on variety species in the Horticulture sector such as TanBIF meant for digitalization and BRAHMS the database used to keep this information for easy access. However, the study also revealed the limitations that these systems have of which the study focused to find ways to solve these limitations and from the analysis, the study achieved its objectives. One of the limitations of TanBIF is that it's not online thus limited access to information to the scientific community. The other limitation of BRAHMS is that it uses DOS which is outdated operating system and cannot be easily used by ordinary users and requires payment of license. The developed web portal is online, easy to use and free of charge to access.

CHAPTER FIVE

CONCLUSION AND RECOMENDATIONS

5.1 Conclusion

The previous chapter presented the results and discussion of this research. It described the analysis and the results found from the research study area and developed application. The chapter also described analysis and the results found from the research study area and the developed web portal for ornamental plants and flowers in Arusha City which stores and retrieves data from the central database through the internet (nabery.com/ornamental). Additionally, the administrator can add information on ornamental plants and flowers, register vendors of the ornamental plants and flowers together with their location, in turn vendors can use the web portal as a marketing tool to connect to regional and international markets. Users of all type can view the list of ornamental plants and flowers on the web portal by vernacular name, English name, family name, genus, native/origin, description of the ornamental plant or flower, the icon of the ornamental plants and flowers, period of propagation, uses in terms of (Medicinal/Herbal, Edible/Food, Poisonous and Ornamental), Conservation in terms of quantity (Extinct in the wild, Extinct, Critically Endangered, Endangered, Least Concern Vulnerable, Nearly Threatened, Data Deficient and Not Evaluated) and also look at the vendors selling the specific ornamental plants and flowers in Arusha City. Additionally, the web portal also provides a visualization tool where a user can be able to interact with and make meaning of the baseline information related to horticulture, small and medium enterprises by vendors in Arusha City. In conclusion, this chapter presents the conclusion, recommendation for the future work and contribution of the study.

Regardless of the observed challenges facing the Horticulture sector in Tanzania such as; the inadequate information for the development of the sector and livelihoods of the vendors. The information on the varied species of ornamental plants and flowers available for sale in Arusha City mainly being undocumented and not digitized limiting knowledge access to the scientific community and the general public bringing on these varieties in Arusha a growing conservation concern. The other challenge is that the small-scale vendors having limited visibility to regional markets and international market places which hinders their business growth. The research found that the majority vendors are enthusiastic to use different methods to be able to access the web portal and use it to market their products and also for the botanists and other types of

users like researchers to access the information on the variety species of the ornamental plants and flowers of which 59.1% of the sampled respondents expressed the need to increase on their visibility on regional markets and international market places to replace the traditional ways of marketing their products as shown in Fig. 33 relying on passersby customers which is not a productive way of marketing.

Figure 33: Traditional Method of Marketing

This great demand for adequate information on the ornamental plants and flowers and the need for vendors to increase their visibility in the regional markets signifies the need to mitigate the observed challenges in order to develop the sector as well as improve the livelihood of the vendors. The findings are also important in a sense that they can help Arusha City Council and the government at large to adopt and improve the proposed technology to be an effective solution against the observed challenges in order to improve on access to important information to the scientific community and general public and also improve on livelihoods of the vendors of the ornamental plants and flowers thus growth of the economy and development of the Horticulture in a long run. More so, improve on the conservation plan of the various ornamental plants and flowers.

Based on the findings from the collected and analyzed data, it was observed that there was a necessity to develop a web portal that can help researchers and the scientific community to retrieve online information on the various species of ornamental plants and flowers and at the same time help vendors have more visibility in the regional markets and international market places as well to improve on the growth of their businesses. The main functional units of the web portal are divided into two groups. First and foremost, are functional units have to be

performed by the administrator, Secondly, are functional units that have to be performed by the vendors and other users such as botanists, researchers, Arusha City Council Representatives and also clients of the vendors for ordering purposes of products advertised by vendors. Therefore, the developed ornamental web portal is expected to reduce the observed challenges in the following ways:

i. To store and provide adequate important information on the variety species of ornamental plants and flowers and location of these species and their location online. for example; information on the ornamental plants and flowers include; vernacular name, English name, family name, genus, native/origin, description of the ornamental plant or flower, the icon of the ornamental plants and flowers, period of propagation, uses in terms of (Medicinal/Herbal, Edible/Food, Poisonous and Ornamental), Conservation in terms of quantity (Extinct in the wild, Extinct, Critically Endangered, Endangered, Least Concern Vulnerable, Nearly Threatened, Data Deficient and Not Evaluated).

ii. To increase the visibility of the vendors in the regional and international market places thus help in growing their business and in turn improve their livelihood. The vendors can advertise their products and clients can order online for the products

In conclusion, the study not only delivered a solution by developing a web based interactive portal able to work together with a central database where this information on variety species can be accessed by all stake holders freely online but also the adoption of the web portal will pave way for biodiversity institutions to digitize their variety collection of the variety species of ornamental plants and flowers in Arusha and Tanzania as whole to be accessed by all stakeholders

5.2 Recommendations

The vendors, botanists, Arusha City Representatives and all stakeholders in developing the horticulture sector in Tanzania should work on these findings and therefore start using the developed web portal for access and digitization of information on variety species of ornamental plants and flowers.

Organizations dealing with integrating ICT into horticulture should sponsor, promote and encourage the use of this portal for access of timely information on variety species of ornamental plants and flowers. This should be done by promoting the benefits of accessing

information on various species of ornamental plants and flowers online and also benefits of using the online web portal as a way to market products by vendors.

It is recommended the portal to have a rating of vendors by user base on the service and quality of purchase items.

The government, policy makers and other stakeholders such as the internet service providers should improve the access to information at affordable prices. More so, the vendors should be empowered with technological know-how as well as with the technical facilities so as they easily serve their clients online.

The portal has potential for sourcing more data on ornamental plants and flowers in Tanzania that can be used to provide useful insights using big data analytics. The future studies should extend further research from access to information on variety species of ornamental plants and flowers and marketing by the vendors only to delivery of other services in the horticulture sector such as mobile transactions for vendors for the products they are selling, using computer vision to identify the various species of ornamental plants and flowers and also further studies can be made non ornamental plants to provide information for industries such as the tourism industry, the scientific community and the general public.

The research recommends the future studies to put emphasis on mobile application development for the vendors to improve usability and also consider an improved approach that involves both qualitative and quantitative methods in order a more real description of the study and findings.

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APPENDICES

Appendix 1: Questionnaire for the Vendors in Arusha City

Table 7 represents a set of questions that were designed in an excel sheet and after, was uploaded in a tool that is used for forms known as "XLSForm Online" then converted the excel sheet to XForms for use with ODK which is an online tool used as an electronic questionnaire instead of paper. There are 3 sheets namely; survey, choices and settings.

Survey

Table 7: Questionnaire (Survey, Choices and Settings)

name	**Label**
gi	**General Information**
note1	"We would like to get background information about the ornamental flowers and plants from your business for research work on Inventory of Ornamental Flowers and Plants in Arusha City. Your participation is voluntary and the information will remain confidential."
district	District Council
ward	Ward
resp_nm	Name of Respondent
resp_sx	Gender of Respondent
age	Age
phone	Phone Number of Respondent
email	Email of respondent
educ	Highest level of Education
smartph	Do you have Smart Phone?
gi	
bizinfo	**Business Information**
year_est	What year did you start the Ornamental flower/plants business?
bizreg	Is your business registered?
year_reg	Which year was your business registered?
orgzreg	What organizations is your business registered with?
owner	Who owns this business?

capital	What is the range of your business capital?
no_empl	How many employees are there in your business?
role	What are your roles in the business?
prod	What range of products do you sell?
flower_exp	What type of flower in your business is the most expensive and how much?
plants_exp	What type of plants in your business is the most expensive and how much?
flower_fast	What type of flowers are fast moving on sales and how much is the cost?
plant_fast	What type of plants are fast moving on sales and how much is the cost?
high_sal	Which months is the high season for selling your products?
low_sal	Which months is the low season for selling your products?
flower_typ	What types of flowers do you have?
flower_name	What are the trade names of these flowers?
flower_scien	What are scientific names of these flowers?
plant_typ	What types of plants do you have?
plant_name	What are the trade names of these plants?
plant_scien	What are scientific names of these plants?
orch_var	What are the names of the orchids varieties?
cost_orch	What is the cost of one orchid flower?
chall_grw	What varieties are challenging to grow?
biz_chal	What business challenges do you have?
period	What time does it take to grow your flowers/plants ?
facility	What special facilities do you use for production?
bizinfo	
mktinfo	**Market Information**
customer	Who are main customers of your products?
bizassist	What kind of assistance do you need to improve your business?
otherinfo	Any other thing you would like us to know about your business?
mktinfo	
photo	**PhotoIDs**
labels	Flowerlabel
flower1	Give the name of flower 1 on the photo for your business

flower2	Give the name of flower 2 on the photo for your business
flower3	Give the name of flower 3 on the photo for your business
flower4	Give the name of flower 4 on the photo for your business
flower5	Give the name of flower 5 on the photo for your business
plant1	Give the name of plant 1 on the photo for your business
plant2	Give the name of plant 2 on the photo for your business
plant3	Give the name of plant 3 on the photo for your business
plant4	Give the name of plant 4 on the photo for your business
plant5	Give the name of plant 5 on the photo for your business
othervar	Mention other important varieties of flowers/plants in your business
gps	GPS

Choices

list name	**name**	**Label**
gender	male	Male
gender	female	Female
yes_no	yes	Yes
yes_no	no	No
district	arusha	Arusha
district	meru	Meru
district	monduli	Monduli
district	longido	Longido
district	karatu	Karatu
district	ngorongoro	Ngorongoro
occupation	trader	Trader
occupation	agent	Agent
occupation	grower	Grower
occupation	govagent	Government Agent

occupation	ngo	Non-Governmental Organization
occupation	florist	Florist
occupation	exporter	Exporter
age	less25	Less than 25 years
age	25to35	25-35 years
age	35to45	35-45 years
age	45to55	45-55 years
age	more55	More than 55 years
education	illiterate	Illiterate
education	primary	Primary
education	olevel	O-Level
education	alevel	A-Level
education	diploma	Diploma
education	graduate	Graduate
education	postgraduate	Postgraduate
product	flowers	Flowers
product	plants	Plants
product	herbal	Herbal
capital	micro	Below TZS 5 million
capital	small	TZS 5 million to TZS 200 million
capital	medium	TZS 200 million to TZS 800 million
capital	large	Above TZS 800 million
bizchallenge	capital	Lack of Capital
bizchallenge	location	Business Location has inadequate infrastructure
bizchallenge	mktchall	Limited Markets of products
bizchallenge	pest	Pest control
bizchallenge	opcosts	High production and operation costs
bizassistance	capital_acc	Access to Capital

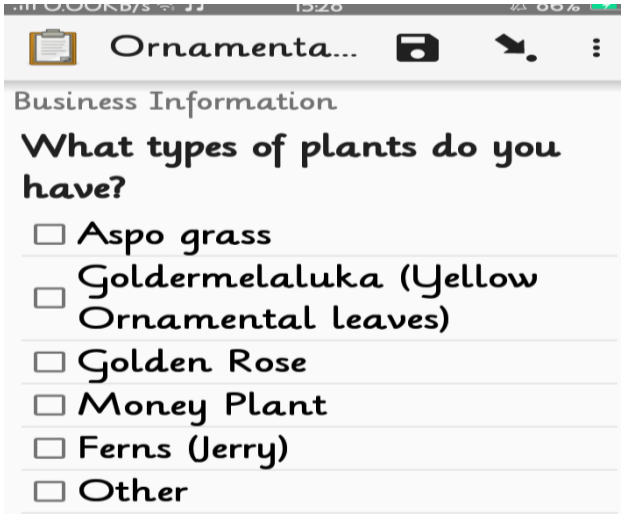
bizassistance	tech_acc	Access to Technology for production of floriculture products
bizassistance	mkt_acc	Support for marketing by specialized agencies
bizassistance	tax	Tax incentives
bizassistance	infras_biz	Business Infrastructure Improvement
facility	natural	Natural and conducive climate condition
facility	greenhouse	Greenhouse/controlled environment
facility	specialmanure	Specialmanure/growth agents
facility	highefforts	Higher efforts in monitoring
facility	nospecial	No special facility is required
flower	rose	Rose
flower	trose	Tube Rose
flower	carn	Carnation
flower	orchid	Orchid
flower	lily	African Lily
flower	jasmine	Jasmine
plant	aspograss	Aspo grass
plant	yellow	Goldermelaluka (Yellow Ornamental leaves)
plant	grose	Golden Rose
plant	moneypl	Money Plant
plant	ferns	Ferns (Jerry)
customer	local	Locals
customer	tourists	Tourists
customer	foreign	Foreign residents
customer	companies	Companies
labels	flower1	Flower1
labels	flower2	Flower2
labels	flower3	Flower3
labels	flower4	Flower4

labels	flower5	Flower5
labels	plant1	Plant1
labels	plant2	Plant2
labels	plant3	Plant3
labels	plant4	Plant4
labels	Plant5	Plant5
labels	othervar	OtherVar
period	lessthan3months	Less than 3months
period	3to6months	3-6months
period	7to12months	7-12months
period	12to18months	12-18months
period	morethan18months	More than 18months

Settings

form_title	**form_id**	**submission_url**
Ornamental_inventory	**ornamentals**	https://docs.google.com/spreadsheets/u/1/d/171coHNEVMbDqOYUCGmgKK-SD-Hx4ZRSiMyRAz9SzcNY/edit?usp=drive_web&ouid=111242470207772433629

Appendix 2: Sample Snippet of ODK Questionnaire



Appendix 3: Questionnaire for the System's Validation and User Acceptance

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THE NELSON MANDELA AFRICAN INSTITUTION OF SCIENCE AND TECHNOLOGY (NM-AIST)

Questionnaire for Tool Acceptance Testing

Ninaitwa Kenneth Patrick Asiimwe. Mimi ni mwanafunzi wa shahada ya uzamili katika Taasisi ya Sayansi na Teknolojia ya Nelson Mandela (NM-AIST), Arusha. Utafiti wangu unahusu kutengeneza tovuti ya mimea na maua ya mapambo yanayouzwa na wafanyabiashara hapa Arusha. Ninategemea tovuti hii itawasaidia wafanyabiashara kuuza bidhaa zao zaidi. Aidha watafiti wengine wa mimea hii na maua watapata njia rahisi ya kupata taarifa za wafanyabiashara waliokuwa na mimea na maua haya. Ninaomba ushirikiano wako kujaza fomu hii kupata maoni yako na mrejesho kuhusu tovuti hii nilioitengeneza.

Note: Weka alama ya vema (∨) mahali husika

Kazi: ……

Tafadhali chagua jibu sahihi katika maswali haya

S/N	**Swali**	Kubali Sana	Kubali	Upande wowote	Sikubaliani	Sikubaliani Kabisa
1.	Tovuti hii ni rahisi kutumia					
2.	Tovuti hii itavutia wafanyabiashara wengi kuitumia kuuza bidhaa zao za maua na mimea.					
3.	Tovuti hii itatusaidia sisi wafanyabiashara kupata taarifa muhimu ya bidhaa za maua na mimea					

4.	Hii tovuti itavutia ofisi za Jiji la Arusha na wafadhili wengine kuwekeza katika kukuza biashara zetu					
5.	Nitapendekeza hii tovuti kwa wafanyabiashara wenzangu wengine wajiunge					

6. Je kuna maoni mengine yoyote unataka kuongezea kwa hii tovuti?

   ……

   ……

   ……

   ……

   ……

   ……..

7. Je ni msaada gani toka Jiji la Arusha unadhani utasaidia biashara yako kukua?

   Mikopo nafuu

   Mafunzo mbalimbali

   Kutungaza biashara zetu

   Ingine: ……

Asante sana kwa mrejesho!

Appendix 4: Sample of the Ornamental Plants and Flowers Taxonomy

Appendix 5: Ornamental Plants and Flowers Taxonomy

English name: African violets

Scientific name: *Saintpaulia goetzeana*

Family: Gesneriaceae

Trade name: African violet

Native: Tanzania and adjacent southeastern Kenya in eastern tropical Africa.

Genus: Saintpaulia

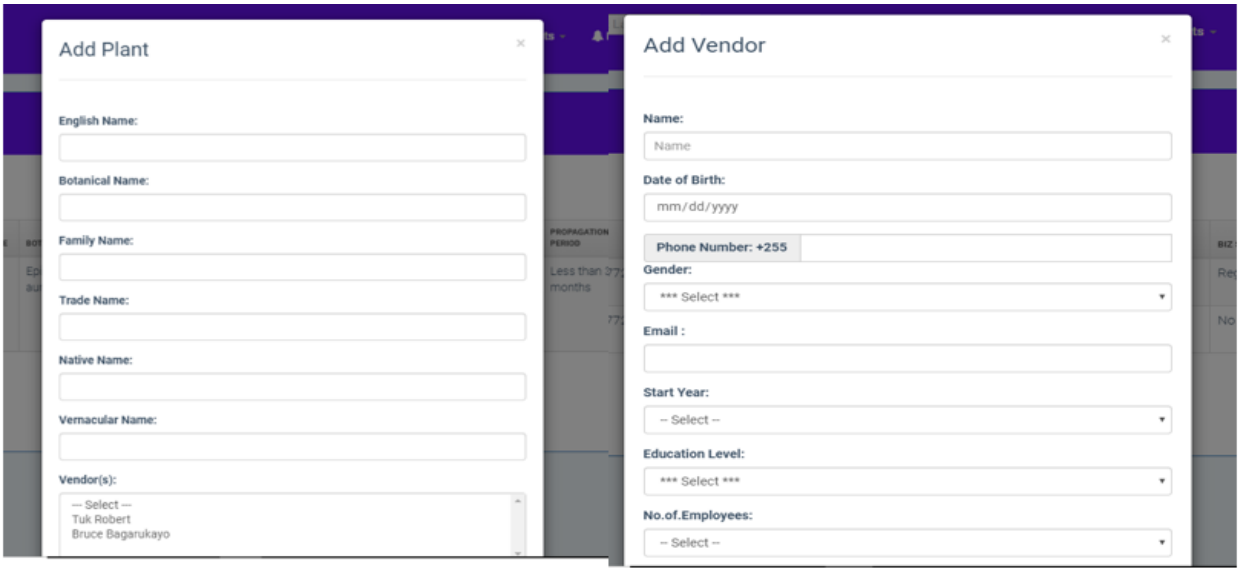
Uses : Herbal,Edible

Conservation status: Nearly Threatened

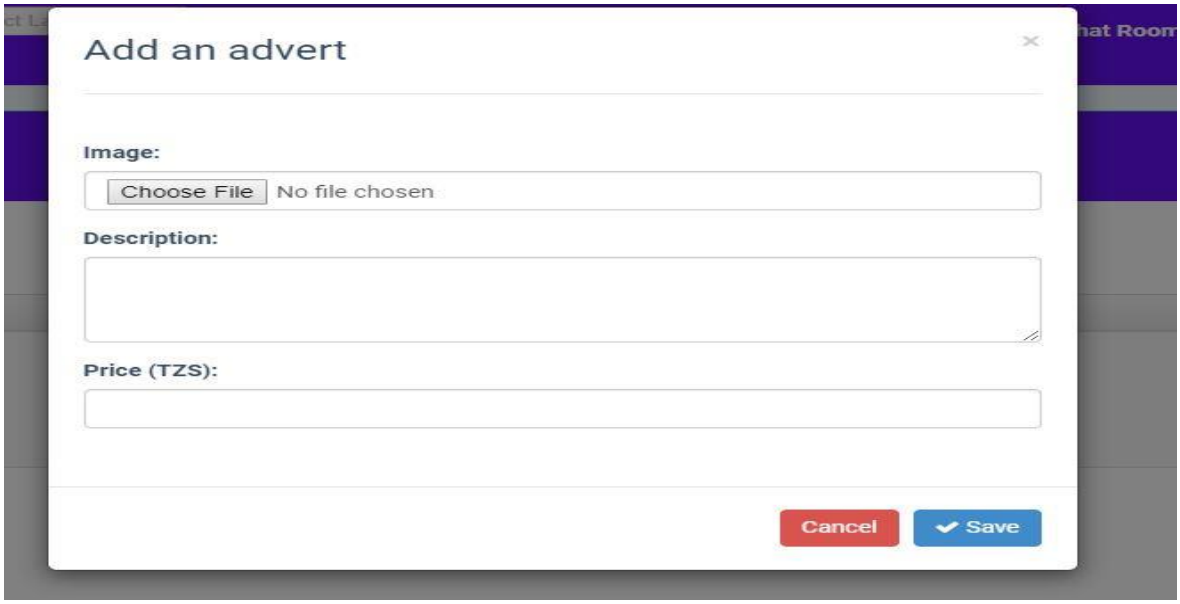
Description: The leaves are rounded to oval, finely hairy, and have a fleshy texture, Wild species can have violet, purple, pale blue, or white flowers.

Propagation period: 3-6 months

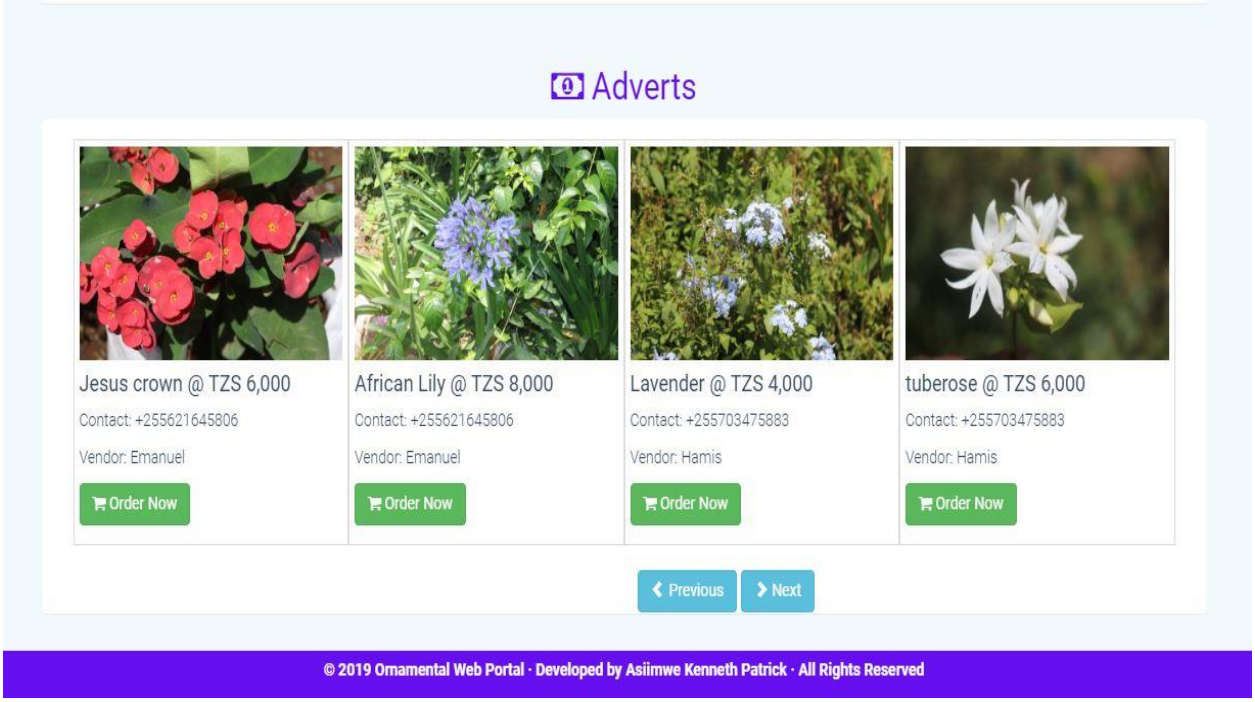
Appendix 6: Screen shot for Plant and Flower and Registration by Admin



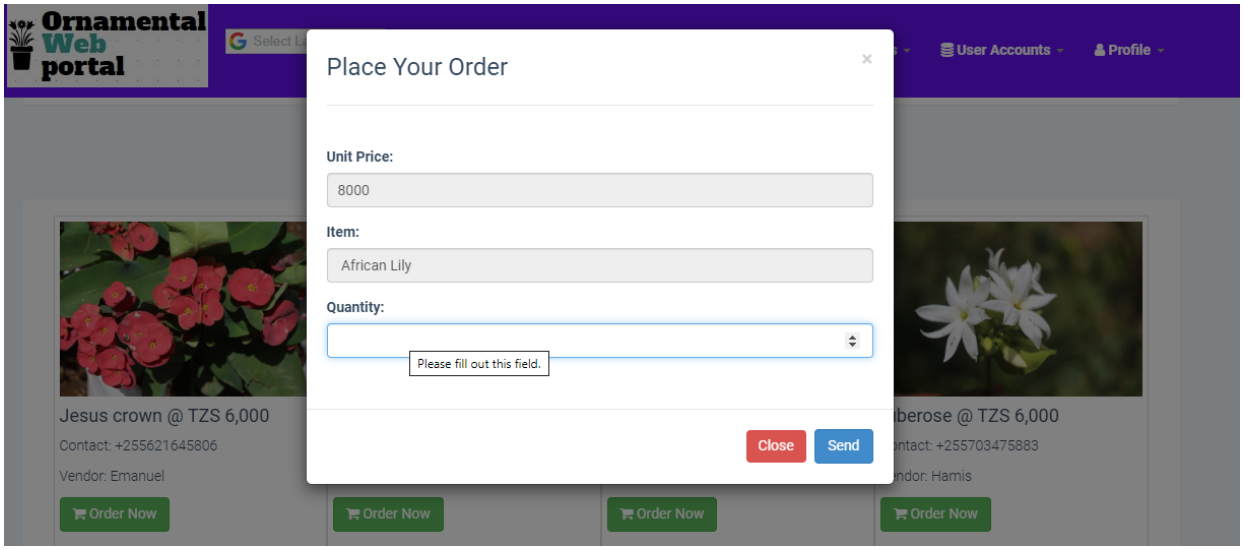
Appendix 7: A Web Page Showing How a Vendor can Create an Advert



Appendix 8: A Web Page Showing Adverts Created by Vendors



Appendix 9: A Web Page Showing Client Placing an Order



Appendix 10: Screen shot showing a Mobile Responsive Web Portal